R Series, Vol. VIII, No. 2 October 1953

PALESTINE JOURNAL OF BOTANY

Rehovot Series

(formerly the Palestine Journal of Botany and Horticultural Science)

EDITED BY
H. R. OPPENHEIMER and I. REICHERT
of the Agricultural Research Station and the Faculty of Agriculture, Hebrew University, Rehovot, Israel

EDITORIAL SECRETARIES:
J. PALTI and S. P. MONSELISE

CONTENTS

REHOVOT, ISRAEL

PALESTINE JOURNAL OF BOTANY

appears in two series

THE REHOVOT SERIES (R)

is edited by H. R. OPPENHEIMER and I. REICHERT, of the Agricultural Research Station, and the Faculty of Agriculture, Hebrew University, Rehovot, Israel. Each volume of this series is scheduled to comprise two issues, totalling 200 – 300 pages.

The subscription price is 18 s. (£0.18—) per volume.

THE JERUSALEM SERIES (J)

is edited by the Staff of the Department of Botany of the Hebrew University, Jerusalem. Each volume of this series is scheduled to comprise four issues, totalling 300—400 pages.

Subscriptions and correspondence concerning editorial or business matters should be addressed:

for the JERUSALEM SERIES: Palestine Journal of Botany, P.O.B. 620, Jerusalem, Israel.

for the REHOVOT SERIES: Palestine Journal of Botany, P.O.B. 15, Rehovot, Israel.

Back volumes of REHOVOT SERIES are obtainable at 18 s. (£0.18.—)
as far as still available.

Moshe Shoham's Press Ltd., Tel-Aviv.

PALESTINE JOURNAL OF BOTANY

Rehovot Series

(formerly the Palestine Journal of Botany and Horticultural Science)

EDITED BY

H. R. OPPENHEIMER and I. REICHERT

of the Agricultural Research Station and the Faculty of Agriculture, Hebrew University, Rehovot, Israel

EDITORIAL SECRETARIES :

J. PALTI and S. P. MONSELISE

Volume VIII

(1951–1953)

REHOVOT, ISRAEL

CONTENTS OF VOLUME VIII

No. 1, November 1951

PALESTINE
JOURNAL OF BOTANY

Vol. VIII, No. 2 *Rehovot Series* October 1953

AN EXPERIMENTAL STUDY ON ECOLOGICAL RELATIONSHIPS AND WATER EXPENSES OF MEDITERRANEAN FOREST VEGETATION

By H. R. OPPENHEIMER

I. INTRODUCTION

Though several valuable contributions to the problem of the ecological adaptation of the Mediterranean maqui have been published during the past fifty years (4; 8—10; 16; 22—24 etc.), our knowledge of the subject is still quite limited and more information on the behaviour of the main species during the dry season is required. In view of the long duration of this season at the south-eastern corner of the Mediterranean Sea, studies of this kind in Israel should be of general interest. They seem even more important from a sylvicultural point of view, as foresters resume the difficult task of establishing mixed forests resembling natural associations in the mountains of this country.

II. THE SITE

The shrubs studied grow on Mt. Heitary, in the Carmel area. While the natural bush vegetation has deteriorated to an open garrigue on the top of the hill which attains 178 metres above sea-level, the northern declivity is still densely covered with maqui shrubs reaching heights of 1.50 to 4 metres. They belong to the association termed by Boyko *Quercetum calliprini lauretosum* (3). Originally, at least part of the bushes composing this maqui have been large trees which have been crippled to present sizes by the axes of the native rural population. We measured stumps of oak trees with diameters of 40 cm. Besides the East Mediterranean kermes oak, *Q. calliprinos,* and the laurel, we find here *Phillyrea media, Pistacia palaestina* and *P. lentiscus* as the main components with *Arbutus andrachne* interspersed here and there. There are further *Styrax officinalis, Rhamnus palaestina,* and the spiny broom *Calycotome villosa* spreading after the larger trees and shrubs have been cut down. *Rhamnus alaternus,* and the climbers *Smilax aspera,*

Lonicera etrusca, Clematis cirrhosa, etc. may also be mentioned. On the black soil typical of oak forests: *Ruscus aculeatus* and seedlings of *Laurus, Quercus, Phillyrea,* and others, grow in the shade. The density of this vegetation is such that it is difficult to penetrate. For our studies, we chose a small glade, about 12 sq.m. in size. Here, we plucked leaves from the surrounding shrubs, for determination of their water expenditure.

Due to erosion by the winter rains, the soil covering the underlying calcareous rock at the site of our investigation was only one to a few decimetres deep. The inclination towards N was about 20°. Analysis of a few soil samples showed that the A_1 horizon was rich an organic matter, losing 27.4—44.9% of its weight on incineration. On the other hand, it was found rather poor in lime, containing not more than 1—3.4% $CaCO_3$.

III. SCOPE AND METHODS OF THE INVESTIGATION

The experiments which we are going to describe, formed part of a research scheme undertaken jointly with Dr. H. Boyko. Our object was to make an ecological survey of the Heitary forest reserve by both plant sociological and physiological methods. Thus, we hoped to arrive at a better understanding of the distribution of forest types, as influenced by exposure and insolation, according to the biological requirements of the component species. Developments beyond our control prevented the completion of this scheme; and publication of the floristic and plant sociological material collected must even now be further delayed.

The main object of our experiments was the evaluation of transpiration rates of four important species of the maqui, viz. *Quercus calliprinos, Pistacia palaestina, Laurus nobilis* and *Phillyrea media.* As in earlier studies, we used the method of weighings at brief intervals by aid of Huber's transpiration balance. These were accompanied by evaluations of stomatal aperture by the infiltration method. At the end of the dry season, we collected some data concerning osmotic values of the leaves, using the cryoscopic method. Climatological data were collected for temperature, humidity (by psychrometer), light intensity on a horizontal plain (by a Lange selen cell), wind direction and intensity, degree of sun covering and cloudiness, as well as for evaporation (by Piche evaporimeter). Some microclimatic data illustrating the large differences in conditions of plant life in northern as compared with southern exposure are included in this publication. They concern soil temperature immediately below the surface, soil humidity at shallow depths of 5-10 cms. and evaporation measured, as a rule, a few decimetres above soil level in sun and shade. For purposes of general orientation on stomatal width and transpiration intensity, we occasionally used Stahl's cobaltochloride method.

Most field methods used in studies of experimental ecology are objectionable from the standpoint of exact science. We feel, therefore, that the manner in which some of our data were collected warrants detailed discussion. When carrying out *thermometric measurements of insolated soil,* we introduced the bulb of the mercury thermometer into the soil so far that the mercury just disappeared. The instrument was kept in a slanting position, its stem shaded by hand or hat, while shading of the soil immediately surrounding the bulb of the instrument was carefully avoided. We exposed *Piche tubes* to direct insolation, and compared hourly or daily figures of evaporation with those obtained in shaded localities; this procedure is highly objectionable to the physicist. Yet, the results obtained are very instructive and useful to the ecologist who is satisfied with data providing an approximative idea of insolation effects. Incidentally, we never observed loss of liquid water exuded through the disk of blotting paper due to expansion of the included air, as might have been expected(25).

The use of the *torsion balance* for the establishment of natural transpiration figures is certainly fraught with serious objections. We are however, convinced that the information on the water expense of plants in their natural habitat, as gained by weighings of isolated organs at brief intervals is basically sound. This applies especially where information is sought on seasonal and specific levels rather than on losses at a certain hour of the day when the results obtained may be far from representative for the whole plant or even for the branch from which the organ is taken for investigation.

Rouschal (23) has investigated the behaviour on the torsion balance of isolated leaves from maqui shrubs. The species he chose are identical or similar to ours. His results demonstrate (except for *Laurus*) that loss in weight diminish considerably under summer conditions after only four or even two minutes. This is probably due to ready stomatal closing reactions. Data for these losses, which later reach a nearly constant level, yield a hyperbolic curve when plotted against time. The matter is further complicated by irregular fluctuations of these losses which are prominent in the results of Ferri and Labouriau (5) with the xerophytic "Caatinga" vegetation of tropical Brazil, e.g. with *Jatropha phyllacantha.* Taking readings of transpiration losses every minute between 14.00 and 16.00 on April 25th, 1946 we met with still larger irregular fluctuations which suggest that, at least under the climatic conditions of that day, transpiration — in analogy to carbon assimilation — is a process changing every moment in intensity. Thus, a leaf of *Q. calliprinos* rendered the following sequence from the second to the seventh minute (in mg per gram of fresh weight per minute): 4.25; 1.68; 1.70; 3.57; 3.57; 0. Corresponding figures for another leaf were: 6.92; 7.10; 3.40; 6.73; 0.0; 3.35. Losses in this species

may rise by over 100% in the second minute, as compared with the first, or drop by nearly 40%, thus obviating the choice of a definite time interval for the establishment of representative losses. A branchlet of *Phillyrea* with 7 leaves behaved more "reasonably", as shown by the following sequence: 3.57; 2.46; 2.35 mg. This was also the case with the following sequence of a laurel leaf: 4.47; 3.53; 3.40; 2.68; 2.90. But irregularity was pronounced with the tender young leaves of the deciduous *Pistacia palaestina*. Probably, the irregular fluctuations found during these few weighings are in part real, being produced by changing insolation and cloudiness, and possibly by rapid changes in stomatal width; some irregularities may also be due to experimental error, since losses during 60 seconds amounted at most to 3 to 5 milligrams, but often only to 1 mg per minute or less.

The technique finally adopted was that of most modern students: leaves from the side of the shrub enjoying the maximum of sunlight were weighed for the first time as soon as possible after their separation from the mother branch, were then brought back to their natural position at the original place of attachment where they were kept for a further 70 seconds and were finally reweighed about 120 seconds after the first determination of their weight.

On three dates during the dry season (April 24th; June 30th; Sept. 21st, 1946) transpiration was studied from dawn to sunset. Every hour 10 leaves or, in the case of *Phillyrea*, branchlets were investigated, 3 each of oak and *Pistacia*, 2 each of *Laurus* and *Phillyrea*. A fourth day of weighings was added on March 24th, 1947, in the hope of completing the picture on a typical spring day, i.e. at a time when neither lack of soil water would be expected to be a limiting factor in water expense, nor would cool and moist weather restrict it.

As to the use of MOLISCH's *infiltration method*, we found its application to our objects by no means easy. Using (a) kerosene; (b) a mixture of terpineol and castor oil in the proportion 2 : 1 and (c) paraffin oil, we are able to make the following statements on their application to our plants including the deciduous Valonea oak (*Quercus aegilops*) and the carob:

(1) In the evergreen *Quercus calliprinos*, infiltration spots can be observed both at the periphery of the drop at the lower side of the leaf or at the upper side(*). In general, the latter practice is preferable. Spots are, as a rule, numerous and distinct at the beginning. On young leaves, it happens that kerosene does

(*) In accordance with common usage, we shall here speak of the "lower" and "upper" side of the leaf in relation to its normal position on the tree and irrespective of the position in which leaves are held during infiltration tests (always applied to the lower side).

not moisten the leaf, forming drops which run off. With this species, infiltration is as a rule restricted in area and slow, indicating small stomatal apertures.

(2) In the Valonea oak, resembling the West-Mediterranean *Q. ilex,* by the hairiness of its lower leaf surface results are difficult, and sometimes impossible to obtain. Infiltration spots often become apparent to the eye where the hairs are rubbed away before the application of the liquids to the lower, hairy side. Their observation from above is easier than from below; results become more conspicuous if part of the upper side, opposite the place of application of the liquid, is smeared with paraffin oil which will not penetrate, if put here. In young leaves results are clearer than in old ones.

(3) In the carob, the spots resulting from application of the liquids at the lower side are easier to observe if looked upon from the opposite, upper side of the leaves. Originally isolated they spread rapidly, occupying entire islets surrounded by tertiary veins. In young, bright green leaves the spots are easier to detect than in old, dark green ones.

(4) In the laurel, it is difficult to perceive the spots. Injected areas look minutely mottled and are conspicuous only when observed from the opposite, upper side.

(5) In *Pistacia palaestina,* spots are often relatively large and isolated from the beginning. They can easily be detected in the old and, still better, in the young leaf, observation being possible from both sides, preferably from below.

(6) With *Phillyrea media,* infiltration tests render excellent results. Numerous spots appear immediately after application of the liquids, facilitating jugment. Even paraffin oil penetrates into the stomata throughout the year.

IV. MICROCLIMATIC DATA

On April 23rd, a dry and hot day at 13:15 p.m., we measured *soil temperatures* on the southern slope of the hill near the Heitary, on top of which the small colony of Bat-Shlomo is situated. The inclination was 10%. Air temperature was 31.7°C, rel. humidity 19%, marking pronounced scirocco conditions. The surface temperature of uncovered soil in the sun was 48.7°C. At the same time, we measured under the cover of dried up grasses (*Avena sterilis*) 40.8°C, in the partial shade of a bushy annual (*Chrysanthemum coronarium*) 34.5°C, and under a stone, lifted immediately before measurement, 32.0°C. The soil was grey.

An even higher temperature was found two hours later on another hill covered with black soil. On the slope slanting at an inclination of 15° towards SSW, the soil surface was heated by the sun up to 50.3°C, while nearby, in the shadow of a bush (*Rhamnus*

palaestina) we measured, 27.8°. The difference appears enormous for a locality no farther than 10 km. from the coast and hardly 100 metres above sea level.

The next day, we carried out measurements on Mt. Heitary, in order to collect data on the differences in northern as compared with southern exposure. On the northern declivity, evaporimetres were hung (1) on one of the uppermost branches of a maqui shrub; (2) on low bushes burnt to the ground 29 months before and still open to the sun rays; (3) in the deep shade of a large oak bush, adjacent to the above mentioned glade. Measurements of light intensity and air temperature were taken in the centre of the glade. Here, the soil was covered with dry remnants of *Bromus alopecuros*.

On the southern slope, we also marked three localities adjoining each other: (1) On bare, calcareous rock inclined towards South at angles of 12-20°. At this place, denuded by soil erosion, grew scattered dwarf bushes, such as *Satureja thymbra, Teucrium creticum, Fumana arabica* and *Phagnalon rupestre*. Here, soil temperature was measured in fissures of the rock. (2) In a less eroded area covered by a xerophilous short grass vegetation of *Stipa tortilis* growing here on very shallow soil. It had already dried up. (3) In the shadow of a few interlocked garrigue bushes (*Phillyrea media, Calycotome villosa,* and *Rhamnus palaestina*). Piche evaporimeters were arranged at heights of 30-50 cms above soil or rock. The outlay resembled arrangements made by WALTER who has earlier done similar work in the Alps(25).

The measurements revealed remarkable microclimatic differences between the above localities differing from each other by soil cover and exposure. They were pronounced even during that early sequence of dry days which is typical in this country for the period of transition from the rainy season to the long, rainless summer. It should be kept in mind that the sun at this period already reaches, at its culmination point, a height of 70° above the horizon.

We learn from table I, summarizing these results that in the "*Stipetum*", soil surface temperature about noon rose by 10 to 17° above air temperature in the shade. By contrast the soil temperature in a shaded place (North) remained about 10° below air temp., while it exceeded the latter in the sun at most by a few degrees centigrade The reduced effect of the sun-rays is, of course, a consequence of inclination away from the sun, towards North and this is also responsible for the large differences in soil moisture. Differences in evaporation are less impressive. The daily sum of water loss above the rock of southern exposure exceeded that in the open garrigue in northern exposure only by 4%, and losses in deep shade were practically independent from the angle of inclination,

amounting to roughly 60% of those in the just mentioned sunny habitats. Contrary to expectation, we found evaporation above the rock to be nearly 10% lower than above the dry *Stipa* stand. We are inclined to attribute this to greater heating of the air by the hotter soil surface in the *Stipetum*, while the probably larger radiant energy of sun rays directly reflected from the rock was relatively unimportant. The relatively smaller evaporation in the maqui, as compared with the nearby habitat with garrigue-like vegetation, is probably to be explained by wind influence which was slighter in the denser and higher maqui.

TABLE I

Microclimatic records collected on Mt. Heitary on April, 24-25, 1946.

Locality	Hour	Air temperature (°C)	Humidity %	Soil temperature (°C)	Total daily evaporation (9:00—17:00) cc	Residual soil moisture %
North, sunny places				In the glade slope about 5°N	In burnt garrigue-like vegetation	
	11.10	31.8	31	36.0	6.40	
	14.30	ca.32	ca.18	34.5	In the maqui	
	17.05	24	47	28	5.35	12.43
	7.40	20.2	75	23		
North, deep shade of maqui shrubs				Under oak		Under oak
	11.10	31.8	31	21.2	3.80	21.95
				Under *Phillyrea* 22.5		Under *Phillyrea* 15.9
South, rock with chasmophytes	9.15	22.2	62	28.6	6.65	
	17.35	24	ca.47	26		
South, *Stipetum*	9.40	27.4		43.5		
	13.30	30.9	27	47.5		
	15.30	25.4	50	35.0		
	17.45	24	47	30.8	7.20	2.12
	8.30	23.2	67	30.0		
	10.40	22	54	36.5		
	17.40	17.5	80	25.5		
South, in shade of garrigue bushes	9.40	27.5		32.5	3.90	4.81

Some further readings of evaporation were taken on June 29, 1946 at Bat Shlomo. Figures were found higher than in April. In the shade of young pine trees, the total daily evaporation of the Piche tubes was 6.2 cc in 12 h 40'. On the southern slope of the Bat Shlomo hill, another tube mounted 40 cm above bare rock, lost 7.9 cc in 13 h 10', and a third one, hanging in the partial shade of a *Capparis spinosa* bush, lost 7.5 during the same period. Again the highest figure, viz 10.1 cc in 13 hours (5.30 a.m.—18.30 p.m.) was established above dry grass, as in April on Mt. Heitary. Indeed evaporation here surpassed that above the rock by 28%. When we discussed the matter with Dr. D. Ashbel, he suggested that heat generated at the surface of the rock is conducted to its deeper layers with relative ease, while rocks covered by dry soil with low thermal conductivity accumulate heat. In any case our findings that on slopes exposed to the full radiation of the sun, shallow soil layers heat up more than bare rock, seem interesting from the point of view of causal plant geography. It is certainly not coincidence that on shallow soil phytocoenoses of a pronounced steppic affinity, such as *Stipetum tortilis,* heat resistant plants, such as *Sedum* or bulbous species are found. The latter disappear with the beginning of the hot season. These localities form, as it were, specifically arid enclaves in the Mediterranean surroundings of our hills.

In order to obtain a first insight into the distribution of light intensities in the leafy tops of maqui shrubs, some readings of light penetrating from above were taken in the maqui of Mt. Heitary, near the above mentioned glade, on April 24th. At 10.00, light intensity on a horizontal plain between bushes amounted to 22 to 37,000 metre candles or, as we may say, 22 to 37 kilolux. When the selenium cell was moved at soil level towards the centre of an oak bush, intensity fell progressively from 7.0 kilolux at the shady periphery to 1.6 kilolux in the centre. At one metre above soil level (half the height of the shrubs), corresponding figures were: 14—3.2 kilolux. Proceeding upwards, along the periphery, figures rose from 14 progressively to 18; 19; 32 kilolux. In a bush of *Pistacia palaestina,* more light was found in the interior. In a vertical sequence near the central branches, light intensity rose from 6 kilolux at soil level to 15 at 1 metre above the soil, and 31 at the top. In a *Calycotome villosa,* corresponding figures were: 4 kilolux at soil level, 7 at one metre's height and 15 at 1.50 m., near the apex.

V. RESULTS OF THE INVESTIGATION ON PLANT TRANSPIRATION IN THE MAQUI

Before proceeding with the description of the results of the main subject of our investigation, we present a short description of the meteorological character of the four days devoted to fixed weighings:

April, 26, 1946, was a rather dry spring day with only slight fluctuations of temperature, which rose at 13:00 p.m. to 24°C, while humidity dropped at 11:00 and 12:00 a.m. to 46%. In both the forenoon and afternoon ,about one half of the sky was covered with clouds, while at noon, cloudiness dropped to near zero. Wind was slight, blowing at noon from a westerly direction. Total daily evaporation (12 hours) measured at a peripheric branch of *Pistacia* in the sun was 6.0 cc, in the deep shade of an oak bush 4.0 cc. Maximum figure in the sun: 0.75 cc per hour.

June, 30, 1946 was a typical, hot summer day. Temperature passed the 30° mark shortly after 10.00 a.m., remaining above it for five hours. At the same time, humidity dropped to little above 50%. Cloudiness was medium, two to four tenths of the sky being covered. Wind was slight, estimated at 1—2 degrees of the Beaufort scale, blowing from West or North-West. Evaporation (6:00 a.m. — 18.00 p.m.) was 6.95 cc in the sun, 3.5 in the shade. Maximum figure in the sun: 0.9 cc per hour.

Sept. 22, 1946 was similar to June, 30 in temperature and humidity but the sky was cloudless throughout. Wind was slight (1—2 degrees) from West or North-West. Evaporation in the sun was 6.1, in the shade 2.9 cc (6:00—18:00) with a maximum of 0.8 cc per hour in the sun.

March, 26, 1947 was a cool spring day, with temperature hardly rising above 20°C. Humidity fell between 12:00 and 14:00 to little below 60%. Cloudiness was low in the morning and afternoon (1/10 to 2/10 of the sky), rising to 5/10 at 10 and 11:00 a.m. Wind was slight (degree 1 in most cases) and from W. Evaporation (6:00 a.m. — 18:00 p.m.) was 3.25 cc in the sun as against 1.50 cc only in shade, with a maximum in the sun of 0.6 cc per hour.

When comparing transpiration readings, it should be kept in mind that on March, 26th, evaporation was by far lower than on the other days which are similar in their climatic character.

Light intensities recorded every hour are noted in table II. Figures appear remarkably high, especially if white clouds reflecting

TABLE II

Total light intensities in the open on a horizontal plane surface in kilolux.

Date	Hour 6	7	8	9	10	11	12	13	14	15	16	17	18
April, 26, 1946	not measured					76	112	97	104.5	83.5	62.5	(?)	
June, 30, 1946	8	41	69	91	112	(?)	137	123.5	106.5	95	72	47.5	13
Sept. 22, 1946		30	46	62	76	79	86	86	68	53	22	9	
March. 26, 1947		30	44	64	(?)	110	114	102	78	66.5	34	55	

diffuse light are present, as was the case on April, 26th, June 30th and March, 26th. On the other hand, they were relatively low, even about noon, on Sept. 22nd which was a cloudless day. The reason was probably the presence of fine dust persisting in the atmosphere after the preceding scirocco day.

The results of our transpiration study are presented in diagram 1 which also shows the air temperature and humidity readings on the respective days. Each point of the curves marks the water loss of a single leaf per 1 gram of fresh weight per minute. We have refrained from smoothing out the curves by replacing single values by hourly averages as these would mean little in view of the large fluctuations discussed above.

1. *Quercus calliprinos* exhibits throughout a transpiration type we propose to term "oligohydric", i.e. low level transpiration which will often prove to be a specific property deriving from structural pecularities and specific physiological adaptations. The transpiration of this species in summer is in fact about three times lower than that of its deciduous relative *Q. aegilops* var. *ithaburensis,* studied at the same time in the neighbourhood (17). In June and September, figures fluctuate throughout the day about 2 or 2½ mg/g.min., rarely reaching 6, and there are several cases where no loss whatsoever could be established with single leaves in the

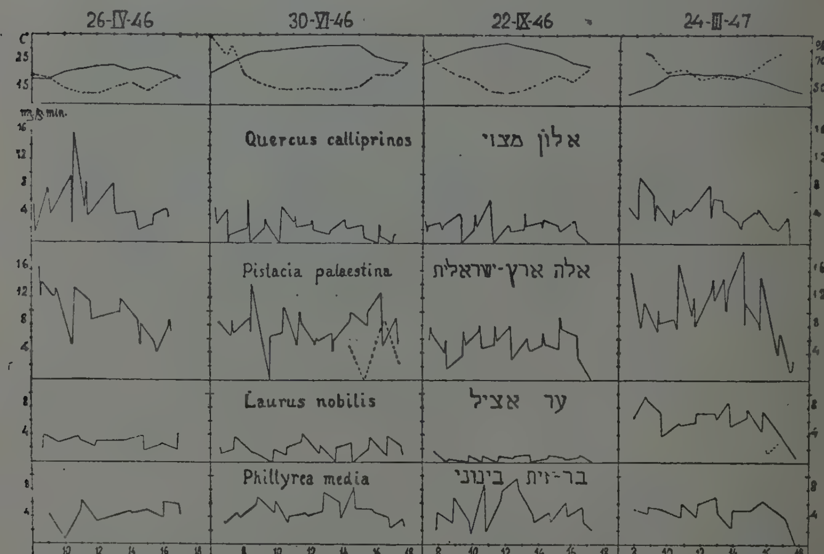


Diagram 1.— Daily march of transpiration of the species investigated on the days indicated. Air temperature (°C) and humidity (%) are shown above.

course of 2 minutes. In the spring, transpiration is about twice as high fluctuating about 4 to 6 mg/g.min., but reaching in the morning hours of March, 24th, nearly 10 and on April, 26th in one case even nearly 16 mg/g.min.

Although the results of stomatal tests often showed tendencies contrary to the results of simultaneous weighings, we nevertheless find some agreement in the general level of stomatal aperture and transpiration intensity. On April, 26th, leaves tested during 2 minutes with LEICK's cobalto chloride paper KP½ (14) turned partially pink even at noon, 20 to 90% of the areas of individual leaves changing colour. On March, 24th, high transpiration figures found about 8:00 a.m. (up to 8—9.7 mg/g.min.), corresponded to wide stomatal apertures. At 8.13 a.m., the two leaves tested showed immediately after application of kerosene complete infiltration of a large area, a result indicating very large apertures which were never found again. The subsequent drop of transpiration rates to the low figure of 3.8mg. at 10:00 a.m. was accompanied by a drop of infiltration figures to II,2 in the scale of PISEK and CARTELLIERI (21), a figure later encountered as a typical average throughout summer.

In June, with transpiration intensity much reduced, we found considerable stomatal aperture only very early in the morning: in addition to kerosene, the terpineol-castor oil mixture then penetrated between 5 and 6 a.m.

The virtual cessation of transpiration subsequently established in three cases before noon corresponds to very low figures of infiltration: at 9:00 a.m., after a steep drop of air moisture to 55%, kerosene no longer penetrated, a result indicating complete closure. The t.-c. mixture likewise penetrated no more and very low stomatal apertures (kerosene infiltration only I,1 to I,2) prevailed throughout the afternoon.

On Sept. 22nd, we found some stomatal opening with slow penetration of the mixture shortly after 7 a.m. only. Kerosene failed to penetrate either at 11 a.m. or at 13 p.m. and aperture continued very low throughout the afternoon. Thus a low level of water exchange seems to be typical for the species throughout the year, transpiration rising to higher figures only in the spring. Narrow vessels in the wood, which do not permit rapid movement of water, correspond to such oligohydric habits of water exchange (11;24). With closed stomata, the tree can achieve a virtual cessation of water loss.

Unpublished transpiration studies on *Quercus calliprinos*, carried out together with EVENARI at Kiryat-Anavim on August, 24th 1933, have previously rendered analogous results. Indeed, transpiration rates of only 3 mg/g.min. were then recorded in the morning hours and considerably less in the afternoon.

2. The laurel (*Laurus nobilis*) has previously been investigated by v. GUTTENBERG (8;9), OPPENHEIMER (16) and ROUSCHAL (23).

All agree that this bush, which in Palestine reaches a southern limit of its distribution, is marked by a specifically low transpiration intensity. Our investigation definitely bears out these earlier findings. At the same time, it shows a very pronounced decrease from relatively high figures in March (fluctuations about 6mg/g.min., with maximum approaching 10) through April (about 3 mg/g.min., as daily average) to June (about 2) and September when the average transpiration drops to less than 1 mg/g.min. Thus we might term the transpiration of *Laurus oligohydric* with respect to its general level and *poikilohydric* with respect to its seasonal fluctuations.

Stomatal behaviour is in good agreement with this yearly march of transpiration intensity. In March, we found very widely open stomata betwen 8:00 and 9:30 a.m. Cobalt paper changed colour completely in 2 minutes when in contact with the lower epidermis of the previous year's (not young!) leaves. The t.-c. mixture infiltrated throughout the day, and so, in one case, did even paraffin oil.

However, in the dry season, the picture changed completely. As early as April, 24th, the cobalto chloride paper failed within a few minutes to absorb any appreciable amount of water vapour from the leaves, even at 7:50 a.m.; infiltration tests proved that the stomatal slits had narrowed considerably, kerosene rendering the result II,3 (numerous spots appearing with some delay) in all samples tested. A further reduction in stomatal width was found on June, 30th. While opening was still considerable in the morning and evening hours (kerosene infiltration II,2 and even II,3), the slits were found almost closed during the hot hours, as indicated by the long delay of infiltration rendering the result I,2. A case where transpiration dropped to the zero level accords with another where even kerosene caused no infiltration whatsoever. Finally, in September we find a general and extreme restriction of stomatal aperture. Only few, scattered spots appeared with long delay, after application of kerosene. Even this was the case only in the relatively cool morning and evening hours, while during the hot period of the day, kerosene did not penetrate at all and the colour of cobalto chloride paper remained completely unchanged. Thus the seasonal march of stomatal aperture furnished convincing evidence that the decline of transpiration in the hot season is intimately linked to and probably mainly brought about by stomatal restriction. The latter eventually makes the leaves practically air-tight, since the closing mechanism is most effective and there are virtually no cuticular losses.

3. With the deciduous *Pistacia palaestina* the situation is quite different. We know from ROUSCHAL's investigation (23) that the similar *Pistacia terebinthus,* which is widespread in the western Mediterranean, is characterised by high transpiration losses, at

least where it enjoys a good water supply. But in the dense maqui of Mt. Heitary stocking on shallow ground, this does not seem to be the rule with *P. palaestina*. It is true that in March when the leaves are very young and tender, transpiration losses were moderately high, fluctuating between 7:45 a.m. and 16:00 p.m. about 13 mg/g.min. and reaching 19 in one case. But already on April, 26th, we note a pronounced downward trend: transpiration rates declined from a similar morning level to only about half as much in the afternoon. In June, the average losses fluctuated about 8 mg/g.min, and occasionally dropped to zero. While most leaves on that day were sampled from the same specimen used in April, another shrub was used for some of our weighings in the afternoon. Keeping the records separate, we found that this plant rendered lower figures; in the diagram, these have been marked by a broken line. This finding confirms a quite similar case reported by Rouschal for *P. terebinthus* (23; p. 477) where the level of water losses of one shrub was 5 to 6 times higher as that of another specimen. The reason for such behaviour probably lies in different development of the respective root systems in the rocky soil. In September, the transpiration level of our *P. palaestina* further dropped to about 5 mg/g.min., with a daily maximum of 9.2 mg instead of the 14.2 mg. recorded in June.

In agreement with the situation depicted in fig. 9 of Rouschal's article, our records concerning *Pistacia* fail to show any pronounced parallelism in the trends of transpiration and stomatal width. Infiltration tests rendered rather low figures even in spring, as is often the case with young and tender leaves; there was little change during the summer, with kerosene rendering results of II,1 to II,3 indicating rather small apertures. A considerable part of the water lost in spring by the immature leaves probably evaporated through the cuticle. Cobalto chloride tests were carried out throughout the investigation on April, 26. Up to 80% of the leaf area changed colour in two minutes, but in the hot hours only 20 to 50% of the leaf area did so.

The results suggest that *Pistacia palaestina* is marked by a rather strong transpiration, where water supply and atmospheric conditions are favourable. We may term its transpiration as meso- to polyhydric as regards its average level and at least as moderately poikilohydric with regard to its fluctuations. Ring-porous structure of the wood and wide vessels facilitate a strong transpiration and render the species similar to *Q. aegilops* and possibly many other deciduous woody plants in its water economy.

4. The behaviour of the fourth species, *Phillyrea media*, contrasts decidedly with that of the three others which restrict their water expense considerably in the dry season. Indeed, here we found surprisingly uniform water loss throughout the year, in spite of the dwindling water reserves of the soil. The diagram demonstrates that

transpiration fluctuated about 5 mg/g. min. at all seasons. This remarkable stability of transpiration is coupled with no less surprising a stability of stomatal aperture in sharp contrast with that of the laurel. Stomata are always wide open, even in September. Not only kerosene and the oil mixture, but even paraffin oil penetrated at that season with little delay (II,1 or II,2, restricted only by light, but not by hydroactive closing reactions). Such behaviour provokes the question why transpiration, unrestricted by stomatal reactions, does not follow the trend of physical evaporation which rises to high figures during summer. There must be some mechanism keeping it down, and we are inclined to assume that the structure of the wood, marked by narrow vessels, functions as a mechanism putting the brake on the transpiration stream. But this is hardly a sufficient explanation ! The water budget of the shrub is probably not well balanced since the osmotic value is known to rise to extremely high figures during the dry season, as found by v. GUTTENBERG and BUHR (10), ROUSCHAL (23) and KONIS (13). Our own findings corroborate their results, as shown below.

VI. OSMOTIC VALUES AT THE END OF THE SUMMER

Restricting the scope of this study essentially to the collection of data on transpiration, we did not investigate water deficits which might have added interesting information about the water balance. Instead, we established a few data on the level of osmotic values which were determined by the cryoscopic method. Leaf samples collected from the bushes used during the investigation on Mt. Heitary on Sept. 22nd at 18:40 p.m. rendered the following osmotic pressures of the sap squeezed out after killing the leaves by heat: *Quercus calliprinos*: 25.7 atm.; *Laurus nobilis*: 36.8 atm.; *Pistacia palaestina* 24.75 and *Phillyrea media* 55.0 atm. The figures for *Quercus* and *Pistacia* do not appear unduly high, pointing to a well balanced water budget, while in the leaf sap of *Laurus* and *Phillyrea* solutes had reached a high degree of concentration which might be interpreted as symptom of a strained water balance.

A second series of samples was collected near the watering place on the road from Zikhron Jacob to Shefeya, where maqui vegetation is encountered in similar exposure as on the Heitary. This was done on Oct. 8th, 1946, before the first effective rains. Samples of *Ceratonia siliqua* and of both *Quercus calliprinos* and *Q. ithaburensis* yielded ample sap, but from leaves of *Phillyrea media,* sufficient sap could be squeezed only with difficulty, and this, as far as we can recall, was also the case with *Styrax officinalis.* Leaves of *Rhamnus palaestina* proved to be so dry that they failed to yield even a drop of sap.

Conforming to the condition of their killed leaves, which evidently still contained much water not bound to the colloids of their cells, the first three species yielded relatively low osmotic

values, viz. *Ceratonia* 14.1 atm., *Q. calliprinos* 20.9 and *Q. aegilops* 20.3 atm. Both Pistacias fell into a medium range which seems to indicate an undisturbed water balance: 24.6 atm. with *P. palaestina* and 24.4 atm. with *P. lentiscus*. Much higher was the osmotic level of the dry samples: 37.5 atm. with *Styrax* and 49.2 atm. with *Phillyrea*.

The figures for *Phillyrea media* show the usual rise to extremely high osmotic values during the summer which is known from the studies of earlier investigators. But this by no means indicates an insufficient adaptation of this plant to its surroundings, as would be expected according to WALTER's well-known views about the ecological significance of this factor. There were no indications of leaf burn or drop, wilting, or any other signs of stress endangering the existence of the plant.

VII. DISCUSSION

Since the present study was from the outset strictly limited in scope it should be looked upon mainly as a stepping stone for future, more extensive studies. Accordingly, the results do not warrant far-reaching conclusions and their discussion can be fairly brief.

1. *Climatic conditions*. Our macro- and micro-climatic data agree with what could be expected. Air temperatures and humidities do not deviate considerably from earlier records in the Carmel region. Evaporation in the shade fits into the frame of routine determinations made in meteorological huts. Thus, monthly averages of daily evaporation, as recorded by ASHBEL(1) for Sha'ar Haamaqim, amounted in March 1939 to 2.8, in April to 2.2, in June to 5.2 and in September to 4.9 mm, while we found in the deep shade of maqui bushes 1.37 mm. on March 24th, 3.91 on April, 24th (under sirocco-like conditions), only 3.19 on June, 30th, and 2.64 on September 22nd(*). The lower figures in the maqui (excluding the figure for April) are probably to be explained by higher humidity and the very low wind velocities prevailing where the evaporimeter was suspended, about one metre above the soil. On the other hand, the results of our study on the Heitary can be compared with the findings of WALTER(25) on the Duerrenstein in Austria where evaporation in the afternoon of a sunny September day reached 0.15—0.55 cc per hour, on a northern slope, in the half-hade of *Pinus montana;* this approaches our values of 0.175—0.53 cc per hour established on the northern slope of the Heitary on the dry April day. These were, however, recorded not in an open locality partially exposed to the sun, but in the deep shade of an oak bush.

(*) Figures obtained through conversion of the observed evaporation in cc from Piche tubes with 3 cm wide disks of white blotting paper, into millimetres evaporating from an open water tank — by multiplication with the factor 0.91.

WALTER recorded in the afternoon 0.8—0.9 cc per hour on the southern slope in the sun. This comes near our own figures (0.75—0.98 cc) for an open locality on the northern slope, on April 24th, while our figures from the sunny localities on the southern slope (up to 1.03 cc per hour above rock and 1.2 cc above the *Stipa* grass-plot, with no fluctuation from 10.00 a.m. to 14.00 p.m.) fall outside the range of his observations. This comparison seems interesting, since it illustrates the considerably greater stress of atmospheric factors in Israel, as compared with Central Europe, at comparable seasons. Differences would be even greater if, like WALTER, we would have used *green*, instead of white, blotting paper, since this author has shown that in the sun the former, by absorbing more energy, yields figures exceeding those obtained with white paper by 32%.

2. *Soil temperatures* reaching 50° centigrade just below the surface, as established by us, are matched by similar observations both in Israel and abroad. OPPENHEIMER and MENDEL have discussed this subject before (19), insisting on the fact that on southern slopes and on bright summer days, soils may become as hot as, and even hotter than in Israel in countries at higher latitudes of about 50°. BOYKO(2) has since published figures from the Judaean desert where he recorded a maximum temperature of 55°C on a horizontal plain (Sept. 5,1945). This extreme temperature equals OPPENHEIMER and MENDEL's finding in a flat, sandy soil (Rehovot, July, 18, 1935). It is interesting to note that, according to LEICK(14), a difference of 36.8°C (59.6—22.8°) was in one case recorded between extreme soil temperatures and air temperatures simultaneously recorded on the Baltic island of Hiddensee on a steep southern slope. This by far exceeds the difference we have published here as an extreme produced by direct insolation of the soil, viz. 22.5° (50.3—27.8°). A similar, relatively low, figure has been published by GODARD(7) from Montpellier where the difference was also about 20°(60—40°). We cannot offer an explanation for the enormous difference found, contrary to expectation, in the cooler and moister climate of the Baltic Sea. Has it been produced by a rectangular incidence of the sun rays, by unknown factors impeding heat conduction or dissipation, or possibly by defective thermometric methods ?

Meteorologists have found that, generally speaking, a grass-lawn has a moderating influence on the heating of soil surfaces. If in this study, we observed the contrary in the *Stipetum* association fragment and on the hill of Bat-Shlomoh, this must be explained by the fact that the lawn and the underlying shallow soil layer were dry and of loose structure. Thus this layer as a whole resembled rather the dry upper layer of cultivated soil which is known to impede heat exchange by its low thermal conductivity and thereby favours overheating.

3. *Transpiration behaviour.* Regarding the level of average

water expenditure, we can easily distinguish *Quercus, Laurus* and *Phillyrea* as evergreen, sclerophyllous plants with a rather low turnover, as opposed to *Pistacia palaestina* with higher transpiration rates. The latter resembles in this respect other deciduous trees, such as almond, fig and the deciduous oak *Quercus aegilops* var. *ithaburensis* on which we reported earlier (14). We propose to term the transpiration of the former group *oligohydric*, that of the latter *polyhydric*. In the former group where transpiration rarely surpasses 8 mg. per gram fresh weight per minute, we find considerable variation concerning the restriction of water expense during the rainless summer. While *Phillyrea* does not seem to restrict its water expense at all, restriction is pronounced with *Quercus* and extreme with *Laurus*. The transpiration of *Phillyrea* in the case investigated by us, may be called *isohydric* because of its unchanging level, and that of *Quercus* and *Laurus poikilohydric*, because of the considerable differences at various seasons. In proposing this terminology for the interpretation of the seasonal march of transpiration in plants, we are conscious of the fact that these expressions are of a relative character and of limited value. Evidently, isohydric transpiration is of rare occurence, while poikilohydric transpiration is the rule. Perhaps it would therefore be preferable to distinguish instead between *stable* and *unstable* transpiration, according to the inherent tendency or capacity of plants to small or large seasonal fluctuations. In so doing, one must, of course, keep in mind that such differences of stability will come forth only under suitable external conditions, as furnished by alternate scarcity and ready availability of water supplies.

Laurus nobilis and *Phillyrea media* have also been investigated by Rouschal by closely similar methods. His conclusions (p. 471) regarding the behaviour of *Laurus* agree with ours, while his findings with *Phillyrea* differ from ours in one respect: Rouschal found this plant in Istria to possess a pronounced *instability* of transpiration in contrast to our own experience.

The daily courses of transpiration are rather too irregular and too uncertain in their details to permit a serious discussion of their dependence upon external factors. Restriction about 8:00 or 10:00 a.m. in the morning, which is found in the majority of the graphs, seems to be essentially a response to a decrease of humidity to about 60%, as evinced by the fact that it occurs in *Pistacia*, *Quercus* and *Laurus*, where soil water is scarce (30.VI.), as well as where its supply is ample (24.III). On the other hand, we are probably entitled to interpret the protracted depression of transpiration during the hot hours (which is so striking in the case of *Quercus* and *Laurus*), as a response to soil drought.

4. *Water balance*. The latter conclusion and far reaching restriction of stomatal aperture show that the water balance in *Quercus* and *Laurus* is maintained in spite of heavy stress. In

Pistacia, the level of water expenditure decreasing from April to September provides a similar indication, though the still considerable level of transpiration in September demonstrates that the plant remains far from any condition threatening its existence. On the other hand, in *Phillyrea* careless expenditure of water combined with invariably open stomata (found also by ROUSCHAL) distinguishes this species from the other components of the maqui. Unlike *Pistacia* or *Quercus aegilops*, *Phillyrea* by this behaviour *cannot* be understood to indicate an easy water balance. The contrary is proved by the enormous rise of the osmotic potential and the likewise enormous water saturation deficit found by ROUSCHAL (which rose during his investigation in 1936 to 72.2% of the water content at saturation). The species appears to possess a quite extraordinary capacity of maintaining its life functions even in a state of extreme plasma dehydration. This can also be substantiated by the enormous *sublethal* deficit determined by ROUSCHAL according to our original method(16). This amounted to 80.5% in 1937 and as much as 91.4% in 1936, i.e.a figure approximating the capacity of survival in air-dry condition exhibited by certain mosses, ferns and lichens. The plasmatic qualities permitting the plant to subsist in spite of so much dehydration, seem to warrant a special investigation.

In our first study on the water ecology of Mediterranean vegetation(16) we distinguished four types with respect to their water balance: (a) Deciduous trees failing to show appreciable stress throughout summer; to this group we now feel entitled to refer *Pistacia palaestina*. (b) Mainly evergreen trees and shrubs physiologically active throughout the summer; with this group we now associate *Phillyrea media*. (c) Evergreen species restricting their physiological activity considerably, thus avoiding losses of irreplaceable water, and finally reaching a state nearing dormancy; among these, we listed in 1932 *Arbutus andrachne*, the laurel, and perhaps erroneously [as suggested by the results of POLJAKOFF(22)] the carob. We can now confirm our earlier statement for *Laurus* and add *Quercus calliprinos* to this group*). (d) Low shrubs with shallow roots and large water deficits in summer, persisting in a state of far reaching dehydration, such as *Rosmarinus*, *Poterium*, etc.

5. *Osmotic values*. Our figures for *Pistacia palaestina* are little higher than those established by KONIS(3) in late July (21.76 atm.) and resemble those found by ROUSCHAL for *Pistacia terebinthus* in August and September (20.97—24.87 atm.). KONIS' figure was found at a time when the water content of the leaves has dropped to 49.2% of their fresh weight; thus it seems probable that a similar state was reached in our *Pistacia* bushes. As to

(*) It seems relevant to remark that groups (b) and (c) are connected by transitional types. This induced us to combine them into one in our survey on water balance in the Near East (18) read before the Seventh International Botanical Congress.

Quercus calliprinos, our final figure of 27.71 atm. is practically identical with KONIS' value of 25.64 atm. which was coupled with a water content of only 46.5% of the dry weight. WRABER(26) has recently published a detailed study on the osmotic value of the leaves of the closely related *Q. coccifera.* After prolonged drought, this figure rose to 23 or 24 atm., exceeding 31 only under very unfavourable edaphic conditions. Our figure of nearly 37 atm. for *Laurus* is considerably higher than the 27.3 atm. found by KONIS. Values so far available fluctuate very much, as is demonstrated by the findings of ROUSCHAL (20.68—30.14 atm.), BRAUN-BLANQUET and WALTER (17.5 atm.) and v. GUTTENBERG (54 atm.) of which the latter may be too high as it was established by the plasmolytic method. The values show that LAURUS is "euryhydric" (WALTER), i.e. adapted to very large fluctuations in the degree of hydration of its protoplasm. The high figure found by us on the Heitary thus suggests a stressed water balance. Probably it corresponded to a state where little free water remained in the leaves.

Our very high figures for *Phillyrea* agree with similar data published by KONIS (40,06 atm.), ROUSCHAL (49.57 to over 60 atm.) and v. GUTTENBERG and BUHR (60.25 atm.) all recorded in the dry and hot season. They are surprisingly high for a glycophyte and must be regarded indeed as indicative of a very far advanced state of dehydration. When KONIS recorded 40.06 atm., this was already coupled with a very low water content amounting to only 44.7% of the fresh weight. These findings point again in the direction of our above statemen: that *Phillyrea* seems to be capable of continuing its life activities in spite of far advanced dehydration of its protoplasm.

With exception of *Phillyrea media* and *Rhamnus alaternus* investigated by KONIS(13), the results so far published concerning the osmotic values of evergreen maqui shrubs in this country agree with BRAUN-BLANQUET's and WALTER's(4) statement that optimum figures range about 18—26 atm. Recent research has shown that with respect to the yearly fluctuations this group is less uniform than those authors believed after analysing them at Montpellier, a locality marking a northern limit of Mediterranean climate and vegetation.

6. *Stomatal behaviour and efficiency of stomatal regulation.* Our results with *Quercus* and *Laurus* corroborate the findings of v. GUTTENBERG(9) who found the stomata of the sclerophyllous evergreens wide open in spring, but practically closed during the dry summer. The structural peculiarities of their leaves permit a practically complete interruption of the transpiration current: this is indicated by the fairly frequent drops to zero which occurred in *Quercus, Laurus* and even *Pistacia,* when the stomata were closed. The very low level of cuticular transpiration of plants with thick-walled and strongly cutinized epiderms is also borne out,

among other studies, by the work of Pisek and Berger (20) and by results of our own earlier investigations (16; 18).

SUMMARY

The author investigated the transpiration of *Quercus calliprinos, Laurus nobilis, Phillyrea media* and *Pistacia palaestina* in their natural habitat by rapid weighings on the torsion balance. The influence of the progressive desiccation of rocky soil, which occurs between April and October, was very pronounced with the two first-mentioned sclerophyllous species. In June and even more in September, transpiration dropped to very low levels, ceasing completely in certain cases during the hot hours of the day. This was brought about by closure of the stomata. *Phillyrea media* behaved in a different manner: its transpiration persisted at an even level throughout the dry summer, and the stomata were always found wide open. This behaviour finally resulted in an extremely high osmotic potential of the vacuolar leaf sap as has previously been established by others. Transpiration of the deciduous *Pistacia* reached a fairly high level in spring, decreasing gradually to a low summer level. Stomata were always found slightly open, lower apertures prevailing at the end of the summer.

With respect to the level of average water expense in the annual cycle, the author proposes to distinguish plants with *oligohydric* transpiration, such as the investigated evergreen *Quercus, Laurus* and *Arbutus,* as well as the conifers, from other mainly deciduous species the transpiration of which is termed *polyhydric*. The term *isohydric* transpiration is used to indicate only slight fluctuations during the year, in contrast to the usual behaviour implying large seasonal fluctuations of average water expense which is called *poikilohydric* transpiration. Accordingly, transpiration of *Quercus calliprinos* and *Laurus nobilis* is characterised as oligo-poikilohydric, that of *Phillyrea* as oligo-isohydric, and that of *Pistacia palaestina* as poly-poikilohydric.

Differential exposure to sun rays produces large differences in microclimatic conditions for plant-life on northern as compared with southern slopes. These are illustrated by records taken at the beginning of the dry season. Differences of temperature and moisture of the uppermost soil layer as well as contrasts in evaporimetric data are very striking (table 1).

In the sun, heating of the surface was found greater in dry grass covering shallow soil than in calcareous rock. This corresponded to higher evaporation above the former and is explained by the better heat conductivity of the rock, favouring thermic exchange with deeper layers.

In the methodological chapter, directions are given for the use of Molisch's infiltration method with leaves of maqui shrubs

and trees. Removal of hairs from the lower side of the leaves before application of the liquids is useful with *Quercus aegilops*. With the investigated oaks, carob and laurel, the infiltration is more conspicuous at their upper than at their lower side where the liquids are applied.

ACKNOWLEDGMENT.— The author is obliged to Dr. S. P. Monselise for devoted technical assistance in the collection of data and their evaluation .

BIBLIOGRAPHY

1. ASHBEL, D. (1950) Annual report. The climate of Palestine and the adjacent countries during the year 5709 (1948/49). Hassadeh library, Tel-Aviv.
2. BOYKO, H. (1947). On the rôle of plants as quantitative climate indicators and the geo-ecological law of distribution. *J. Ecol.* 35: 138—157.
3. BOYKO, H. (1947). A laurel forest in Palestine (Lauretum quercetosum infectoriae). *Pal. J. Bot. Rehovot Series* 6 : 1—13.
4. BRAUN-BLANQUET, J. & WALTER, H. (1931). Zur Ökologie der Mediterranpflanzen. *Jb. wiss. Bot.* 74: 697—748.
5. FERRI, M. G. & LABOURIAU, L. G. (1952). Water balance of plants from the "caatinga", *Rev. Brasil. Biol.* 12: 301—312.
6. GIACOBBE, A. (1939). Ricerche geografiche ed ecologiche sul Laurus nobilis. *Archivio botan.* 15(*N.S.*5) : 33—82.
7. GODARD, M. (1944). Radiation solaire et échauffement de la surface du sol. *C. R. Acad. Sci. Paris,* 219: 624—626.
8. v. GUTTENBERG H. (1907). Anatomisch-physiologische Untersuchungen über das immergrüne Laubblatt der Mediterranflora. *Englers bot. Jahrb.* 38 : 383—444.
9. v. GUTTENBERG H. (1927) Studien über das Verhalten des immergrünen Laubblattes der Mediterranflora zu verschiedenen Jahrszeiten. *Planta* 4: 726—779.
10. v. GUTTENBERG, H. & BUHR, H. (1935). Studien über die Assimilation und Atmung mediterraner Macchiapflanzen während der Regen-und Trockenzeit. *Planta* 24: 163—265.
11. HUBER, B. (1935). Die physiologische Bedeutung der Ring-und Zerstreutporigkeit. *Ber. d. bot. Ges.* 53 : 711—719.
12. KILLIAN, CH. (1932). Recherches écologiques sur les fluctuations saisonnières de la transpiration chez les végétaux du climat méditerranéen. *Bull. Soc. bot. Fr.* 68: 460—501. 69: 187—220.
13. KONIS, E. (1949). The resistance of maquis plants to supramaximal temperatures. *Ecol.* 30 : 425—429.

14. LEICK, E. (1927). Untersuchungen über den Einfluss des Lichtes auf die Öffungsweite unterseitiger und oberseitiger Stomata desselben Blattes. *Jb. wiss. Bot.* 67 : 771—848.

15. LEICK, E. (1932). Aus der Arbeit der biologischen Forschungsstation Hiddensee. *Pommersche Heimatpflege* 3 : No. 3.

16. OPPENHEIMER, H. R. (1932). Zur Kenntnis der hochsommerlichen Wasserbilanz mediterraner Gehölze. *Ber. d. bot. Ges.* 50a : 185—245.

17. OPPENHEIMER, H. R. (1947). The water turn-over of the Valonea oak. *Pal. J. Bot. Rehovot. Series* 7 : 177—179.

18. OPPENHEIMER, H. R. (1951). Summer drought and water balance of plants growing in the Near East. *J. Ecol.* 39 : 356—362.

19. OPPENHEIMER, H. R. & MENDEL, K. (1939). Orange leaf transpiration under orchard conditions. *Pal. J. Bot. Rehovot. Series* 2 : 171—250.

20. PISEK, A. & BERGER, E. (1938). Kutikuläre Transpiration und Trockenresistenz isolierter Blätter und Sprosse. *Planta* 28 : 124—155.

21. PISEK, A. & CARTELLIERI, E. (1931). Zur Kenntnis des Wasserhaushalts der Pflanzen. I Sonnenpflanzen. *Jb. wiss. Bot.* 75 : 195—251.

22. POLJAKOFF, ALEXANDRA (1945). Ecological investigations in Palestine. I. The water balance of some mediterranean trees. *Pal. J. Bot. Jerusalem Ser.* 3 : 138—150.

23. ROUSCHAL, E. (1938). Zur Ökologie der Macchien. I. *Jb. wiss. Bot.* 87 : 436—523.

24. ROUSCHAL, E. (1937). Die Geschwindigkeit des Transpirationsstromes in Macchiengehölzen *Sitzber. Akad. Wiss. Wien, Math. -nat. Kl. Abt.* 1 : 146, 119—133.

25. WALTER, H. (1928) Verdunstungsmessungen auf kleinstem Raume in versciedenen Pflanzengesellschaften. *Jb.. wiss. Bot.* 68 : 233—288.

26. WRABER, M. (1950) Zum Wasserhaushalt von Quercus coccifera. *Vegetatio.* 3 : 266—278.

GROWTH ANALYSIS OF CITRUS SEEDLINGS
II. A COMPARISON BETWEEN SWEET LIME, ROUGH LEMON AND SOUR ORANGE

By S. P. MONSELISE
Faculty of Agriculture, Hebrew University, Rehovot.

I. INTRODUCTION

In a previous article (5), the present author reported on net assimilation rates — related both to leaf weight and leaf area (E_w and E_a) as well as on relative growth rates (R) of sweet lime seedlings growing either in the open or under cover. Since these were the first values of E and R calculated for citrus seedlings, it was considered desirable to corroborate these findings by further investigations. It was also felt that a comparison between seedlings of the main citrus rootstocks used in this country and the possible establishment of specific differences would prove interesting also from a horticultural point of view.

II. METHODS

In our previous work a rather extensive period of growth of sweet lime seedlings was investigated. Nevertheless no definite trends of E and R with time could be detected. This is probably a consequence of the periodicity of growth peculiar to woody perennials and of the marked variability of the seedlings. It was therefore deemed desirable to carry out the present analysis on replicate samples at the harvest interval chosen for investigation, while the extension of analysis to numerous harvest intervals was not held to be worth the amount of labour involved. Three citrus rootstocks were therefore studied at a single harvest interval of two weeks, with 4 replicate sets of 10 seedlings of each species, i.e. with a total of 240 seedlings.

The seedlings grew in medium sandy loam at the Government Citrus Demonstration Station, Zerifin (Sarafand). Thanks are extended to Mr. D. Zirkin, Head of the Section of Nurseries, Ministry of Agriculture. for kindly permitting the use of the nursery stock required.

Seeds had been sown in a cold frame in January 1950 and the seedlings transplanted in May 1950 at distances of 25 cms. to nursery rows 50 cms. apart. The growth period investigated extended from August 24th to September 7th, 1950. Nothing unusual, from a climatological point of view, was recorded during this period which consisted of normal, clear, hot summer days (mean daily maximum and minimum for this period: 32.9 and 20.8°C, resp.). The calculation of E and R was performed as in our previous paper (5). The formulae used are repeated here.

$$R = \frac{\ln W_2 - \ln W_1}{t_2 - t_1} \quad (I)$$

$$E = \frac{W_2 - W_1}{L_2 - L_1} \bullet \frac{\ln L_2 - \ln L_1}{t_2 - t_1} \quad (II)$$

W_2 is total dry weight at time t_2, W_1 at time t_1; L_2 and L_1 may be either leaf area (La) or leaf weight (Lw). Accordingly, formula (II) yields values of Ea and Ew. Dimensions of E and R used in the present paper are those indicated in the headlines of table II.

The correction of the mean of natural logarithms of total weight per seedling and of leaf weight per seedling, by means of regression equations on logarithm of rectangular leaf area (maximum breadth by length) measured at the time of first harvest, was carried out as described in our earlier article (5). Ea was calculated after reduction of circumscribed rectangular leaf areas to actual areas and calculation of prospective leaf areas at the date of the second harvest from corrected leaf weight. The figures obtained are therefore somewhat less dependable than Ew values.

The fact that the soil was a medium sandy loam and not a light sand as in our previous investigation, had an unfortunate influence: roots could not be completely recovered. It was decided therefore, to carry out all calculations on tops only. The term total weight, as used in this paper, means therefore weight of aerial parts only (shoots with leaves).

Leaf weight and leaf area refer to blades only in the cases of sweet lime and rough lemon, while the broadly winged petioles of sour orange have been considered as an integral part of the leaves. Altogether about 5700 leaves have been measured and 48 regression equations calculated.

In order to obtain at least some information on the specific share of root weight in total weight for sour orange and sweet lime, 20 more seedlings of each species were investigated. Sown in January 1952 they were planted in May 1952 at the same distances as stated above in a soil very similar in texture to that used during our experiment at Zerifin. The seedlings were dug out on September 12th, 1952, and great care was taken to recover the maximum amount of their roots.

III. RESULTS

A. *Relation between rectangular and planimetered areas of leaves*

In our previous work the regressions allowing calculation of actual areas of leaves from the product of length by maximum breadth (and conversely) had been established for sweet lime seedlings. The same was done for seedlings investigated in the present study, on random samples of about 65 leaves for each species, collected at the second harvest date. The results are reported in table I.

TABLE I.

Relation between actual (x) and "rectangular" (y) areas of leaves in different species and correlation coefficients (r) between them

Species	(*to calculate* x)	(*to calculate* y)	r
Rough lemon	X=1.288 +0.6339y	Y=1.5253x—1.234	0.983
Sweet lime	X=0.329 +0.7002y	Y=0.404 +1.3910x	0.987
Sour orange	X=0.6051y—0.158	Y=0.770 +1.6184x	0.990

The coefficients of regression (b) for sweet lime compare well with those for leaves from uncovered plots calculated previously (bxy=0.7031; byx=1.403). The difference between bxy for sweet lime on the one hand and bxy for rough lemon and sour orange on the other is highly significant. By contrast, the coefficients of rough lemon and sour orange do not differ significantly. It must be remembered that the broadly winged petioles of sour orange are included in the calculation of leaf areas, while this is not the case for both the lemon-like varieties, the petioles of which are almost wingless.

Coefficients of correlation between x and y are very high in every case.

B. *Net assimilation and relative growth rates; leaf area and leaf weight ratios*

An analysis of variance as usual for randomized block design, was carried out for R, Ew, Ea, Lw/W and La/W, although for reasons beyond our control species were not randomized within blocks. Such a procedure is justified by the relative uniformity of the soil and the relatively small area of the whole experiment.*) The results of the experiment are presented in table II. The variance for species with two degrees of freedom was split into two portions, with one degree each, allowing comparisons (a) between sour orange and the lemon-like varieties and (b) within the latter group as suggested in section 11.6 of SNEDECOR's books (6). F tests for these comparisons provided a criterion of significance. In every case differences within the group of the lemon-like species were not significant, while at least the .05 level of significance was attained in the tests of differences between sour orange and both the lemon-like species investigated, in every character except relative growth rate.

TABLE II.

Averages of relative growth rates (R,gm/100 gm day), net assimilation rates in relation to leaf weight (Ew,gm/100gm day) and leaf area (Ea, gm/sq.m day), leaf weight ratio (Lw/W, gm/gm), and leaf area ratio (La/W, sq. dm/gm) for different species

Species	*R*	*Ew*	*Ea*	*Lw/W*	*La/W*
Rough lemon	2.940	5.224	4.942	0.562	0.595
Sweet lime	2.842	4.929	4.484	0.577	0.629
Sour orange	2.006	2.982	2.606	0.677	0.770
Standard errors of difference between means (degrees of freedom for error: 6)	0.476	0.709	0.598	0.011	0.032

*) Dr. P. G. HOMEYER, of the Iowa State College, while on a F.A.O. mission to Israel, kindly helped in taking this decision and suggested the splitting of variance used below.

IV. DISCUSSION

The results of table II concerning R and E are in accordance with expectation as sour orange is known to be slower in development than both the investigated species of lemon-like rootstocks. It is not very surprising that the differences are relatively small. While the ultimate results of growth of a whole season are spectacular, the rates of growth and synthesis do not differ so much when calculated on the basis of one day's time and only due to the "compound interest law of growth" the differences become eventually very conspicuous. The latter statement holds true also in this case, as the average of the aerial parts of 40 sedlings was on September 7, 1950: sweet lime — 10.41 gms., rough lemon — 9.21 gms. and sour orange — 2.97 gms.

While values of Ew and Ea are significantly lower (at the .05 level) in sour orange than in both other species, values of R are not. This may be explained by the fact that both Lw/W and La/W ratios are significantly *higher* (at the .01 level) in the former species than in both the latter. As Blackman and Wilson have stressed recently (1) R is the product of Ea by La/W and it may be added that it is also the product of Ew by Lw/W. As trends of Ew and Ea on one hand and Lw/W on the other, are opposite in the lemon-like species as compared with sour orange, differences between their products (R) tend to be smoothed down, as a consequence.

The fact that the derived data are based on aerial parts only introduces an error which cannot be easily evaluated. By a look at formula (I) one is easily convinced that little change is to be expected for R if the weight of subterranean organs is added to the aerial parts. This is true, of course, only on condition that in the time interval investigated no major changes in the top-root ratio take place. On the other hand, according to formula (II) values of E when calculated from aerial parts only, must be lower than when calculations are based on whole seedlings.

Only a few statements on the differences to be expected are found in the literature. Watson (8) states that no great difference was found in one experiment with wheat between values of Ea calculated from total dry weight including all roots recovered and from dry weight of shoots alone. It may well be that roots have only a secondary importance with regard to their influence on the estimates of E in the case of wheat, where top-root ratios may be very high — 4 to 5, according to Harris (3), — as compared with sweet lime, where this ratio amounts only to 1.4—1.6 at the age of about 4 months after transplanting from seed bed (5). — For barley and corn, Turner (7) has shown that T/R ratios grow larger with age, averaging 5 to 6 at the age of 6 to 7 weeks. With oats Williams (9) has shown that values of Ew, calculated from shoots only, ranged from 50% to 80% of estimates from whole plants, in the early stages of growth, but differences were not significant near the flowering stage.

When comparing our present with our previous results, we may therefore compare values of R without important corrections, while with regard to values of E, allowance has to be made for root weight. E values have to be increased proportionally to that part of the total increment in weight which must be attributed to root growth. If, as we shall see later, roots, under the prevailing conditions make up about 30% of total seedling weight, values of Ew calculated from tops only will amount to about 70% of the values calculated from whole plants.

From our earlier experiment with sweet lime, estimates of R, Ew and Ea for uncovered plots at the eighth harvest interval have been calculated for entire plants as well as for tops only and the data are presented in table III. Root weight in that case made up about 40% of total weight in both samples.

TABLE III

R, Ew and Ea calculated from tops and from whole sweet lime seedlings growing in light sand (dimensions as in table II)

	R		*Ew*		*Ea*	
Whole plants	2.674	100%	6.982	100%	5.058	100%
Tops only	2.769	104	4.256	61	3.128	61.5

The soil of the nursery at Zerifin is a medium sandy loam, as already stated. It is very probable that this fact caused an increase in T/R ratios as compared with values found in sand. A better supply of nutrients probably took place in sandy loam. It has further been shown by TURNER(7) that abundance of available nitrogen tends to increase the T/R ratio. A raise in this ratio would tend to reduce the corrections which must be made in E values calculated from tops only. Let us, for example, compare the value of Ew from tops only (4.256), as quoted in table III, with the corresponding value of 6.982 when whole plants were taken as basis for calculation. The increment in root weight over the interval involved was in this case about 40% of the total increment in growth, the T/R ratio being about 1.5. Now in table II, 4.929 is the value of Ew for sweet lime seedlings, grown at Zerifin, calculated for tops only. In order to make this value correspond to the same 6.982 (of table III) evaluated for whole seedlings, the T/R ratio must be assumed to be about 2.4 and the increment in weight attributable to roots only about 29.5% of the total. These or similar changes in T/R ratio and percentage root weight may indeeed be brought about by the factors mentioned above. In the additional set of sour orange and sweet lime seedlings uprooted in 1952, the averages of root weight expressed as percentage of total weight were 29.5% in sweet lime and 30% in sour orange. This seems to lend weight to the above discussion.

In conclusion it may be stated that the results of the present experiment compare well with the figures of Ew found previously, although it should perhaps be pointed out, that the Ea value found at the 8th interval in our previous experiment, was higher than most other values. This interval has been used for comparison as it extended in 1947 approximately over the same period of August and September as our present work in 1950.

As we deal with three different species it must be asked whether by any chance the T/R ratios might differ in the species involved. If this were the case, values of E would have to be corrected by multiplication with different factors (increasing with decreasing T/R) in the different species and figures for E in different species, as reported in this article, would not be comparable.

Hardly any difference in T/R ratios was found between the sour orange and sweet lime seedlings investigated in 1952 (2.28 ± 0.09 and 2.32 ± 0.07, respectively). It seems therefore that differences in growth and assimilation, amongst different citrus species, can be attributed to whole plants, even if they have been calculated from tops only.

Specific differences in Ea have already been demonstrated by others. In a recent paper Watson (8) has shown differences in Ea between cereals and root crops, in contrast to the view previously held by Heath and Gregory (4) that Ea is more or less constant for widely different conditions and genera. This is likewise suggested by our findings: a comparison of sweet lime seedlings of similar developmental stages grown in sand in 1947 (e.g. 4.740 gms/sq.m day mean Ea for eighth and ninth harvest intervals) with those grown in medium soil in 1950 (4.484 for Ea from tops, i.e. about 6.40 after correction for whole plants) suggests a more intensive synthetizing activity in the latter year and the heavier soil. It should be kept in mind, however, that the two sets of experiments are not strictly comparable.

The fact that values of R and E in the present study are somewhat higher than our previous findings, does not invalidate our view that woody plants are less active in assimilation and growth than annuals or herbaceous perennials (5). Recent work by Goodall (2) supports this view. It must be noted however that Watson (8) has reported on differences between cereals and root crops which may be due to cultural conditions, but may alternatively indicate a lower activity for certain monocotyledons than for dicotyledons. Values for wheat and barley as reported for June-July in fig. 5 of the cited article (about 6.4 to 7.1 gm/sq.m day) do not seem to differ considerably from values for sweet lime or rough lemon (about 6.4 and 7.0 if roots share about 30% of total weight) but are much higher than values for sour orange, calculated as above (3.7). Values for cacao are much lower: 1.03 on the average for

the period of 6 to 30 weeks from planting (2). According to data by BLACKMAN and WILSON (1) obtained from pot experiments, *Hordeum vulgare* has higher Ea values in full daylight, viz. 10.7 gm/sq.m day. This is higher than values reported in the same paper for many dicotyledons.

The ratio of leaf area to total weight (La/W) is rather low in our experimental material, and, if correction for lacking root weight could be made, it would be even lower. For the sake of comparison some La/W values from BLACKMAN and WILSON'S (1) work are reported below:

Lycopersicum esculentum	213 sq.cm/gm
Solanum dulcamara	150 sq.cm/gm
Pisum sativum	116 sq.cm/gm
Vicia faba	75 sq.cm/gm

With most other species figures range from 100 to 200 sq.cm/gm. In cacao they range from 75 to 140(2). Citrus seedlings (values calculated from tops only) range from 59 to 82. For whole seedlings about 40 was found with sweet lime and only 26 with trifoliate orange (5).

Leaf-weight—total-weight ratios (Lw/W) have not been reported in literature as often as La/W ratios, but it can be stated that our values are of about the same magnitude as those of WILLIAMS (9) for *Phalaris tuberosa* in the P_2N_1 and P_2N_2 treatments. Lw/W ratios for whole seedlings in our 1952 measurements were 0.416 gm/gm for sweet lime and 0.470 gm/gm for sour orange; similar values were obtained from table II assuming roots to represent 30% of total weight, viz. 0.400 for rough lemon, 0.404 for sweet lime and 0.474 for sour orange.

As a consequence of low Ea and Ew values in conjunction with low ratios of leaf areas and leaf weight to plant totals, very low values of R result in citrus seedlings. Some recent estimates of relative growth rate are quoted below for comparison (1):

Lycopersicum esculentum	13.5	gm/100 gm day
Hordeum vulgare	12.5	gm/100 gm day
Trifolium subterraneum	11.5	gm/100 gm day
Helianthus annuus	10.1	gm/100 gm day
Pisum sativum	6.2	gm/100 gm day
Vicia faba	4.2	gm/100 gm day

For rough lemon, sweet lime and sour orange, estimates of R are, in this study, 2.9 2.8 and 2.0, respectively. *Theobroma cacao,* a very slow growing perennial, evinces the even lower value of 1.29(2).

SUMMARY

Net assimilation rates of 9 months old sour orange have been found to be significantly lower than those of two lemon-like citrus rootstocks (sweet lime and rough lemon). Relative growth rates were also lower, though not significantly so as lower net assimilation rates of sour orange seedlings are partly compensated by a relatively larger proportion of leaf surfaces and weights.

These results have been obtained from the study of aerial organs only, but evidence is produced that the relative size of root systems does not differ very much at this early stage. Therefore the conclusions are probably applicable to the whole plants as well.

Data obtained for sweet lime compare well with data from previous experiments, if due allowance for root production is made.

BIBLIOGRAPHY

1. Blackman, G. E. and Wilson, G. L. (1951). Physiological studies in the analysis of plant environment. VII—An analysis of the differential effects of light intensity on the net assimilation rate, leaf area ratio and relative growth rate of different species. *Ann. Bot. N. S.* 15:373—408.
2. Goodall, D. W. (1950). Growth analysis of cacao seedlings. *Ann. Bot. N.S.* 14:291—306.
3. Harris, F. S. (1914). The effect of soil moisture, plant food and age on the ratio of tops to roots in plants. *J. Am. Soc. Agron.* 6:65—75.
4. Heath, O. V. S. and Gregory, F. G. (1938). The constancy of the mean net assimilation rate and its ecological importance. *Ann. Bot. N. S.* 2:811—818.
5. Monselise, S. P. (1951). Growth analysis of citrus seedlings. I—Growth of sweet lime seedlings in dependence upon illumination. *Pal. J. Bot. Rehovot series.* 8:54—75.
6. Snedecor, G. W. (1946). Statistical methods. Iowa State Coll. Press, 4th ed.
7. Turner, T. W. (1922). Studies of the mechanism of the physiological effects of certain mineral salts in alterating the ratio of top growth to root growth in seed plants. *Am. J. Bot.* 9:415—445.
8. Watson, D. J. (1947). Comparative physiological studies on the growth of field crops. I—Variation in net assimilation rate and leaf area between species and varieties, and within and between years. *Ann. Bot. N. S.* 11:41—76.
9. Williams, R. F. (1946). The physiology of plant growth with special reference to the concept of net assimilation rate. *Ann. Bot. N. S.* 10:41—72.

IDENTIFICATION OF CITRUS STOCKS BY COLORIMETRIC METHODS *)

By E. JUNGWIRTH
Faculty of Agriculture, Hebrew University, Rehovot

I. INTRODUCTION

Citriculturists often desire to identify the stocks on which mature citrus trees are budded. Yet this is often rendered difficult by the lack of aerial organs originating immediately from the stock. The shape of stock and scion at the bud union, while being of help in some cases, is not always a reliable indication nor even sufficiently characteristic for a given stionic combination.

Colorimetric methods have been devised and used by several authors (1, 2, 3, 4, 5, 8, 9). They are based on colour reactions by means of several reagents, using aqueous extracts of dried bark and leaves. The character of these reactions is still unknown. Generally speaking, different workers have obtained similar results, but the colours reported for certain species do not always agree. It may therefore be supposed that climatical and genetic differences may induce various clones of citrus species to react in different ways to the same reagents. In any case the results obtained in a given locality cannot as yet provide a reliable basis for practical application in any other citrus growing region and with other varieties of a given species.

Some confusion is also introduced by the use of colour descriptions such as light-brown, very light brown, etc., which are both subjective and indeterminate.

A substantial improvement in colour descriptions has been introduced by Bacchi (1) and by Masters (9), who used colour photography, but apart from the technical difficulties in printing such photographs, this technique seems to provide an approximation of true colour rather than its faithful reproduction.

Colour standards painted for the purpose may be useful. Marloth (private communication) and Masters (9) have used such charts. Colour atlases provide us with a ready set of standards, but the comparison of painted charts with coloured solutions is not wholly unbiased.

---

*) Abridged translation of a Master's thesis carried out under the guidance of H. R. Oppenheimer and S. P. Monselise.

Printed with the help of the Zvi Hellman fund, with kind permission of the Hebrew University.

The present study has been carried out for the following purposes:

1) to find out an objective method of colour description which will allow ready comparison of results obtained on different occasions;

2) to ascertain the colour reactions of several citrus root-stocks grown in the coastal plain of Israel and compare them with available data collected elsewhere;

3) to establish whether different stocks and scions influence the colour reactions of their partners;

4) to test the differences in colour reactions between extracts from various parts of the same tree;

5) to investigate the dependence of colour reactions upon the taxonomic relationship between genera and species;

6) to try to collect useful data towards the interpretation of the chemical reactions involved.

II. MATERIAL AND METHODS

Bark and leaves were collected from trees growing in two groves of the Agricultural Research Station at Rehovot, Israel. One grove is planted with Shamouti orange trees budded on nine different stocks, and with unbudded seedling trees of the same stocks. The age of these trees was about 18 years. In the second grove, varieties belonging to several citrus species are grown on sour orange stock.

The following reagents were used:

(a) "Almén" reagent — mercury and nitric acid 1:1, as described by HALMA (3), b) ammonium molybdate, and c) titanous chloride, as described by HALMA and HAAS (4), and finally d) ferric chloride as originally described by HENDRICKSEN (5).

Bark of the trunk was used in most cases, since this was the practice adopted by most previous workers. Bark of young and old roots, twigs, incompletely as well as fully developed leaves, flowers, and different portions of the peel of fruits were sometimes used for comparison.

The solutions obtained from extracts treated with the above mentioned reagents were evaluated for colour intensity and tint, compared with a colour atlas (7) and sometimes tested with a Coleman's Universal photo-electric colorimeter. With the aid of this instrument light transmission through the above solutions was tested, for wavelengths ranging from 400 to 800mμ, at intervals of 25mμ, using suitable filters.

III. RESULTS

A. *Objective evaluation of colour*

Coleman's Universal colorimeter yielded useful data for extracts treated with the Almén reagent. The curves obtained from

the same species on different occasions were quite similar in shape and differed only slightly in the area covered.

B. *Colour reactions with different citrus species*

Results obtained with different species and reagents are presented in Table 1. The numbers and symbols in brackets correspond to specifications in the colour atlas (7). Fig. 1 summarizes light transmission through extracts from the bark of unbudded stocks treated

TABLE I

Colour reactions of bark extracts from various citrus species and varieties

Variety	*Almén*	*Ammonium molybdate*	*Ferric chloride*	*Titanous chloride*
Sweet orange	purplish pink (30 C2-5, A3-6)	light green (19 6-8 C, D)	brown (turbid)	yellowish brown (turbid)
Sour orange	light orange brown (12 6-7, BC)	dark bluish green (27 L 10-12)	dark brown (clear)	light greenish brown
Sweet Lime	almost colourless (purple tint)	grayish blue	yellowish brown (turbid)	light brown (turbid)
Sour Lime	reddish brown (5 G-H 10, 11)	green (20, 9-10 IJ)	blackish brown	dark green
Sour Lemon	light reddish brown (4, AB 10-11)	dark green (27, 8-10 IJ)	brown (clear)	green
Rough Lemon	almost colourless (purple tint)	dark prussian blue	light brown (clear)	light yellow
Grapefruit	almost colourless	blue (36 L 1-2)	light yellowish brown (turbid)	light brownish yellow (turbid)
Shaddock	almost colourless (purple tint)	light bluish green (27 K 8-10)	light yellowish brown (turbid)	light brownish yellow (turbid)
Citron	dark reddish brown (5, G-H 11-12)	dark green (26, 3-5 IJ)	dark reddish brown (clear)	dark green
Tangerine	almost colourless	——	light brown (turbid)	light brown (turbid)
Clementine	light purplish pink (50 2-3 B)	green (19, 8-9 EF)	brown (turbid)	light brown (turbid)
Tangelo	almost colourless	light bluish green (25, 1-2 J)	light brown (turbid)	light yellow
Tangor	purplish pink (50, 3-6A, 3-5B)	——	brown (turbid)	light brownish yellow
Kumquat	light golden brown (11, CD 1)	see below (*)	brown (clear)	dark yellow
Bergamot	light orange brown (12 BC 6-7)	green (19,10—11 L)	dark brown (clear)	light greenish brown
Trifoliate	almost colourless	light bluish green (26, 5-7 BC)	dark yellow (clear)	almost colourless
Limequat	light reddish pink (3 EF 8-9)	light green (19 AB 10)	very dark brown (clear)	very light green

(*) Colours obtained with Kumquat varieties by ammonium molybdate only: (1) Nagami—green (18, 9 EF); (2) Meiwa—bluish green (27, 10-11K); (3) Marumi—greenish blue (28, 7-8L).

with the Almén reagent. It will appear at once that only that portion of the curve between 400 and 600 mμ deserves attention as above 650 mμ most curves show closely similar courses. In the section below 650 mμ we can easily distinguish "colourless solutions" with high, and "coloured solutions" with low transmission.

Four of the colourless extracts — those obtained from sweet lime, rough lemon, grapefruit and shaddock — yielded transmission curves of similar shape (the main feature being a secondary maximum at 475 mμ) while the fifth (obtained from the trifoliate orange) had peculiar trends which render it easily distinguishable from others. Some minor differences in the position of the main maximum can be perceived in the curves of the sweet lime, rough lemon and trifoliate orange on the one and those of grapefruit and shaddock on the other hand (maxima at 600 and 625 mμ, respectively).

Among the coloured solutions, the maximum relative transmission of which is always at 650 mμ, the following differential features may be noted:

sour orange — the transmission curve takes a horizontal course between 475 and 525 mμ;

sweet orange (Shamouti) — two peaks including a secondary maximum at 450 mμ;

sour lemon and citron — transmission increased slowly up to 550 mμ and then much more rapidly towards the maximum.

A comparison of our results with those of other workers is presented in Table II. It cannot be based on objective colour determinations and we have consequently to content ourselves with verbal

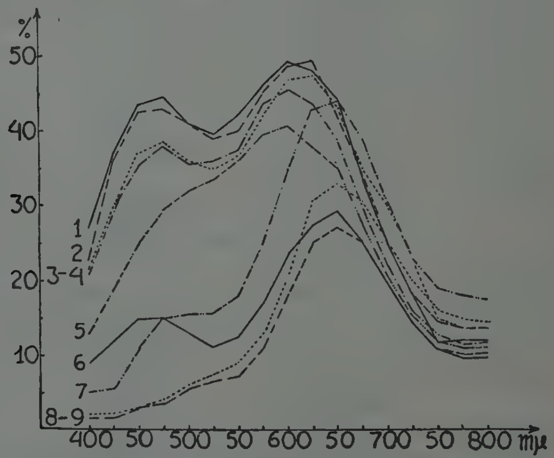


Figure 1.— Light transmission through extracts from the bark of unbudded stocks treated with the Almen reagent. 1) sweet lime, 2) grapefruit, 3) shaddock, 4) rough lemon, 5) trifoliate orange, 6) sweet orange, 7) sour orange, 8) citron, 9) sour lemon.

descriptions. BACCHI's results have been translated but the description in the original language is sometime added in brackets.

Only results with the Almén reagent are compared. It should be pointed out that we are inclined to agree with BACCHI's views regarding the value of the ammonium molybdate reagent. As already shown by that author and also partly by MARLOTH (8), it is very difficult to prepare this reagent at the originally proposed pH value. We obtained better results at about 3 to 3.5. We did not try the "optional reagent" as proposed by MASTERS (9). Under the conditions of our investigations, as previously under those of BACCHI's, the molybdate reagent did not render satisfactory results.

When comparing the data of table II, it must be remembered that MASTERS used proportions of bark extracts and Almén reagent

TABLE II

Results with the Almén Test as obtained by different authors

Variety	*Halma & Haas* (4)	*Marloth* (8)	*Bacchi* (1)	*Jungwirth*	*Masters* (9)
Sweet orange	pink	pink	purplish pink (roseo-violeta)	purplish pink	light rosolane purple
Sour orange	brown	light brown	light brown (marron clara)	light orange brown	Cinnamon, ochraceous buff, zinc orange
Sweet lime	——	——	almost colourless	almost colourless	Persian lilac
Sour lime	——	light pink	——	reddish brown	——
Sour lemon	rusty red	dark brown	dark brown (marron escura avermelhada)	light reddish brown	brick red
Rough lemon	very light pink	almost colourless	almost colourless	almost colourless	pale vinaceous lilac
Grape-fruit	light pink	light brown pink	almost colourless	almost colourless	vinaceous lilac
Shaddock	——	almost colourless (purple tint)	light brown	almost colourless (purple tint)	ochraceous buff
Citron	——	very light brown	almost colourless	dark reddish brown	——
Tangerine	——	almost colourless	almost colourless	almost colourless	vinaceous lavender
Trifoliate orange	——	almost colourless (green tint)	almost colourless	almost colourless	Persian lilac
Kumquat	——	almost colourless (green tint)	almost colourless	light golden brown	——
Limequat	——	very light brown/green	——	light reddish pink	——
Tangelo	——	light pink	purplish pink	almost colourless or purplish pink	pale rosolane purple to Persian lilac

differing from those of the others. This might have influenced his results and produced light tinges where other authors found colourless solutions. On the other hand, the results of the other authors including our own should be readily comparable.

A few remarks to table II seem indicated:

1. *Sweet lime*: Sometimes we obtained a pinkish tinge — see MASTERS (9). On the other hand, the colour "light pink" of MARLOTH (8) belongs probably to a *sour* lime, although this is not definitely stated.
2. *Sour lemon* and *citron*: Discrepancies between the indications of authors who investigated these species are probably due to varietal differences. In any case it should be noted that the term of Ridgway "Brick red" does not seem to be a correct notation for the colour presented in the chart of MASTERS' paper. We should prefer to call this colour: "dark brown."
3. *Tangelo*: The variety originally used by us was "Nacotee" (colourless). We tried a few more varieties with the following results: "Sampson"—pink, "Thornton"—pink, "Bialik" (a local variety) — colourless.

C. *Colour reactions as influenced by stionic relations*

(a) ONE VARIETY BUDDED ON DIFFERENT STOCKS

Bark of the trunk from Shamouti orange trees budded on nine different stocks was tested with the Almén reagent. The stocks were: sour orange, sweet lime, grapefruit, shaddock, citron, sour lemon, rough lemon, "Baladi" and "Shamouti" sweet oranges.

When extracts were judged by the naked eye, only differences in colour intensity, but not in quality could be detected. Apparently they are not due to stock influence, since they appear also among replications of the same stionic combination. By supplementary tests with Coleman's colorimeter of Shamouti bark extracts from specimens budded on sour orange, sweet lime and rough lemon stocks, we were, however, able to reveal interesting differences in the position of the peaks of the transmission curves. As apparent from Fig. 1, extracts from unbudded sour orange stock pass the highest percentage of light at 650 mμ, whereas extracts from unbudded rough lemon and sweet lime do so at 600mμ, The maximum transmission in extracts from Shamouti orange budded on either rough lemon or sweet lime stocks *occurred at* 625 *mμ*, on sour orange stock at 650 mμ. Several unbudded Shamouti seedlings likewise yielded the latter figure. Thus transmission in Shamouti both on rough lemon and on sweet lime was at its maximum at a wavelength intermediate between the unbudded stocks and the scion grown on its own roots.

(b) DIFFERENT VARIETIES BUDDED ON THE SAME STOCK

Extracts from sour orange stocks budded with different citrus varieties were tested by means of the Almén reagent. The varieties

were: Bearss' Seedless lime, Moanalua shaddock, Dancy tangerine, Avana (willow-leaf) mandarin, Marsh's Seedless and Duncan grapefruits, Lisbon lemon, Valencia Late and Ruby oranges. Here again no differences were apparent to the naked eye except in the intensity of colour. A colorimetric test showed, however, similar features to those mentioned in the preceding paragraph. Sour orange extracts from stock budded to shaddock and grapefruit scions evinced maximum transmission at 625 mμ, while in most other cases the maximum was found at 650 mμ. We learn from Fig. 1 that bark extracts of shaddock and grapefruit evince maximum transmissions below 650 mμ, the normal maximum of the sour orange. Of several unbudded sour orange stocks none ever failed to show the maximum at 650 mμ. There appears, therefore, to be a small but definite influence of the scion on the bark extract of the stock.

D. *Differences in colour reactions between different parts of the same tree*

Apart from the bark of the trunk, roots have already been used by others in colorimetric tests [HENDRICKSEN (5); BACCHI (1), and others]. On the use of leaf extracts divergent views have been expressed by different authors. While MARLOTH (8) rules out the use of leaves, FURR and REECE (2) have used them with success when testing young seedlings for breeding purposes.

Proceeding on the same line, we have compared extracts from different parts of the trees. The Almén reagent was used throughout. Table III summarizes the results obtained with unbudded 18 year old stocks.

TABLE III

Colour reactions of extracts from different parts of Citrus trees (Almén reagent)

Variety	*Young roots*	*Bark of old roots*	*bark of trunk*	*bark of twigs*	*mature leaves*	*youngflush*
Sweet orange	almost colourless	purplish pink	purplish pink	light reddish pink	reddish pink	vinaceous red
Sour orange	almost colourless	light orange brown	light orange brown	light orange brown	light yellow.'pink	reddish pink
Sweet lime	almost colourless	almost colourless	almost colourless	light pink	reddish pink	vinaceous red
Sour lemon	almost colourless	reddish brown	light reddish brown	——	light yellowish brown	light yellowish brown
Rough lemon	almost colourless	almost colourless	almost colourless	almost colourless	light reddish pink	reddish pink
Grape-fruit	almost colourless	very light purple	almost colourless	——	light yellowish brown	light pinkish brown
Shaddock	almost colourless	very light purple	almost colourless	——	as above	as above
Citron	almost colourless	dark reddish brown	dark reddish brown	——	almost colourless	——
Tri-foliate	almost colourless	almost colourless	almost colourless	——	——	light yellowish brown

Colour reactions of other organs of sweet lime trees:

(1) *Flowers*: dark pink

(2) *Fruits*—albedo: light pink
flavedo: dark pink

A perusal of this table demonstrates that *young rootlets* (1—1.5 mm thickness) produced only colourless solutions. (The same extracts developed typical differential colours when treated with ammonium molybdate.)

Other parts of the tree rendered distinct colour reactions according to species. The most intense and dark colours were found in *immature leaves* of the new flush on the one hand, and in bark of *mature roots* (more than 4 mm thick) on the other. Bark of trunk and twigs showed colour reactions which were intermediate, resembling more closely those of the roots or of the leaves, according to the topographical position on the tree of the sample collected. Colour reactions obtained with mature, and even more with immature, leaves lie within too narrow a range to permit a reliable identification of the species. If we consider together the results reported in table III and others (not reported in full) which were obtained with leaves of budded trees, we may arrange species and varieties in three main groups according to colours of extracts from immature leaves and in seven groups according to those from mature leaves. These groups are shown in table IV.

TABLE IV

Arrangement of different citrus species and varieties in groups according to Almén reaction of extracts from their leaves.

A. *Undeveloped leaves*	
1. *Vinous red*	sweet orange sweet lime tangerine
2. *Reddish pink*	sour orange rough lemon tangor (Temple)
3. *Light pinkish brown to light yellowish brown*	sour lemon grapefruit shaddock bergamot trifoliate orange

B. *Mature leaves*	
1. *Vinous red*	tangerine clementine
2. *Reddish pink*	sweet lime sweet orange sour lime tangor (Temple)
3. *Light reddish pink*	sour orange rough lemon
4. *Pink*	tangelo
5. *Light yellowish brown*	sour lemon grapefruit shaddock bergamot limequat
6. *Light orange brown*	kumquat
7. *Colourless*	citron

E. *Dependence of colour reactions upon taxonomic qualities*

In order to find out whether colour reactions of this kind are specific to the Orange sub-family (which belongs to the family of

Rutaceae), the following trees belonging to another group of the same family or to families close to or remote from it were tested:

Casimiroa edulis (the white sapota)	Rutaceae
Mangifera indica	Anacardiaceae
Olea europaea	Oleaceae
Eucalyptus sp.	Myrtaceae
Ceratonia siliqua (the carob tree)	Leguminosae
Ficus nitida	Moraceae

All the above species are evergreen like the citrus species. In each case of extracts of the bark of the trunk and of leaves were tested with both Almén and ferric chloride reagents. The olive tree tested with the Almén reagent rendered positive results with both bark and leaf extracts. Casimiroa, with the same reagent, yielded slightly coloured solutions from the leaf extract only. With ferric chloride most species yielded very dark solutions which had to be diluted for appraisal of their colour (proportion 1 : 1 and even 1 : 4 in the case of mango). According to KLEIN (6) phenol compounds produce a green coloration with ferric chloride. Leaf extracts from most species mentioned above yielded green colours with this reagent.

As regards trees of closer taxonomic relationship to citrus, it is interesting to note the different trend of the transmission curves which distinguishes *Poncirus trifoliata* from the true citrus species (Fig. 1).

Colorimetric tests will possibly prove useful in elucidating the identity of certain citrus species and varieties, the systematic position of which is not yet clear, e.g. of the *rough lemon.* The identity of this variety with other lemons has been debated by authors who used colour producing reagents (HAAS and HALMA, MARLOTH) and with whose results our data agree (see table II). Indeed, the relationship between this lemon variety and true sour lemon types does not seem to be very close. The true taxonomic position of the *Palestine sweet lime* is not known. WEBBER (10) considers it a hybrid of unknown origin (perhaps of citron and sour lime). Yet no similarity between reactions of sweet lime and those of either of the presumed parents could be found (see table I). The *bergamot* is generally considered a very close relative of the sour orange (*C. aurantium*, subsp. *bergamia*). Trunk bark extracts rendered results very similar to those of sour orange (see table I), but according to leaf extracts we may group it with sour lemon, grapefruit and shaddock. It may perhaps be considered to be a hybrid of sour orange with one of the last mentioned species. An interesting supplementary hint is provided by the fact that the petiole wings of the bergamot resemble those of the shaddock rather than those of the sour orange. The *Meiwa kumquat* is sometimes considered a hybrid of the Nagami

and the Marumi varieties. In fact, the Meiwa bark extract yielded with ammonium molybdate a colour intermediate between those of the two other kumquat varieties (see table I and the corresponding colours in the atlas). The *Clementine mandarin* which has been considered a hydrid between *C. reticulata* and a sport of the sour orange is considered by WEBBER (10) to be simply "a variant within the mandarin group or, if it is a hybrid between species... its character suggests a slight mixture with the sweet orange". The results shown in table I actually seem to point to a much closer relationship with sweet orange than with sour orange, thus adding weight to WEBBER's view.

F. *Experimental evidence regarding the nature of the colour reactions*

The solvents tested in place of water were ethyl alcohol, diethyl ether, and acetone. Bark extracts were prepared and tested in the usual way. After the extractions, the residue was dried at 70°C until free from traces of solvent and another extract was made, this time with distilled water for comparison. We tried by this procedure to elucidate whether (1) the compounds responsible for the colour reactions of the aqueous extracts can be dissolved by other solvents and (2) whether the reactions take place also in other than aqueous media. The results are reported in table V.

TABLE V.

Effects of solvents on the production of colours by reagents

	Colour reaction in alcoholic extracts	*The same in aqueous extract of the residue*
Almén	negative	positive
Ammonium molybdate	positive	negative
Ferric chloride	negative	positive
	in ether extracts	*in aqueous extract of the residue*
Almén	not tested*)	negative
Ammonium molybdate	not tested*)	negative
Ferric chloride	negative	negative
	in acetone extracts	*in aqueous extract of the residue*
Almén	not tested*)	indeterminate
Ammonium molybdate	not tested*)	indeterminate
Ferric chloride	indeterminate	indeterminate

*) Not tested since the reaction requires high temperatures, but no technical equipment to overcome the difficulty arising with ether and acetone solutions was available.

The table shows that the use of alcohol yielded different results with Almén and ferric chloride on the one, and with ammonium molybdate on the other hand. This seems to substantiate our view that the compounds responsible for the reactions obtained with the former reagents probably differ from those involved in reactions with the latter. The ether extract did not react with ferric chloride, nor did aqueous extracts of the residue react with either Almén or any other reagents. It would appear, therefore, that ether either destroys or precipitates the compounds responsible for the reactions. Acetone extracts and aqueous extracts of the residue rendered only very indistinct results.

IV. DISCUSSION AND GENERAL CONCLUSIONS

Generally speaking, results obtained with colour tests by different workers agree fairly well. Much variation probably derives from varietal differences. Some of it may be due to differences in stionic combinations. MASTERS (9), using fairly concentrated extracts, succeeded in fact in detecting such influences. Where not detectable by the naked eye these could be demonstrated by instruments, such as photoelectric colorimeters. The evidence obtained during the present study can hardly be interpreted in favour of the view that climate will modify results, although this may be true in other cases. Many of our results agree quite closely with those obtained in Brazil, South Africa and California (e.g. with sweet, sour and trifoliate orange, tangerine, etc.) while the results of MASTERS who worked in California, very often differ from those of other authors, including Californians.

Interaction of scion and stock, which becomes apparent in almost every stion by anatomical and physiological features, could also be demonstrated in this study. It must be pointed out, however, that bark of stocks and scions was lifted for investigation only in the neighbourhood of the bud union. More comparisons of leaf extracts of budlings and seedlings will have to be carried out, in order to establish whether stionic influences can be detected in every part of the tree, even at greater distances from the bud union.

A problem not yet sufficiently elucidated is the connection of colours originating from hybrids with those of their parents. The accurate comparison of hybrids and parents presents considerable difficulties to anyone not engaged in breeding work of his own. From this point of view the investigation by FURR and REECE(2) is most interesting. Their study demonstrates that there are actually some relations between colours obtained from extracts of parents and their offsprings. This conclusion is also borne out by at least one of our results (parentage of Meiwa kumquat) while other results are somewhat inconclusive.

So far nobody has tried to elucidate the mechanism of the colour reactions in question, although some authors have stressed

the necessity of such investigation. Results of the present study and research carried out elsewhere seem to prove that the classes of compounds involved in the reactions with the Almén reagent differ from those reacting with ammonium molybdate. Thus, young rootlets never yielded colours with Almén, while molybdate produced specific tinges. Moreover, compounds reacting with molybdate can be extracted with alcohol, while those reacting with the Almén reagent can not. Different amounts of the same compound, or possibly different compounds, are present in different parts of the same tree. This is true not only for the organs which differ widely in shape and functions, such as roots and leaflets, but also for bark lifted from different places of trunk and twigs.

We are here confronted with a very complicated and interesting problem the solution of which must, however, be left to the biochemist.

SUMMARY

Several citrus species and varieties grown as stocks, scions and unbudded seedlings have been investigated by colorimetric methods. (Almén, ammonium molybdate, ferric chloride and titanous chloride reagens) Bark of trunks was used in most cases.

Coloured solutions were sometimes tested by means of a photoelectric colorimeter; this refinement in technique allowed to draw transmission curves for different species as a substitute for simple colour description. It also allowed to detect stionic influences undetectable by the naked eye.

Aqueous extracts of different organs of the same tree yielded different tinges with the same reagent: most intense colours were found with undeveloped leaves and bark of mature roots, while new rootlets rendered colourless solutions.

It has been found that colour reactions are not specific for *Citrus* only, as bark from trees belonging to different botanical families has also been found to react.

Although the mechanism of colour reactions remains unexplained, it has been found that compounds responsible for reactions with ammonium molybdate are alcohol soluble and differ from those reacting with the Almén reagent.

BIBLIOGRAPHY

1. Bacchi, O. (1943). Identificação colorimétrica em citrus. *Bragantia.* 3:179—191.
2. Furr, J. R. and Reece, P. C. (1946). Identification of hybrid and nucellar citrus seedlings by a modification of rootstock colour test. *Am. Soc. Hort. Sci. Proc.* 48:141—146.
3. Halma, F. F. (1934). Scion influence in citrus. *J. Pom. Hort. Sci.* 12:99—104.
4. Halma, F. F. and Haas, A. R. C. (1929). Identification of certain species of citrus by colorimetric tests. *Pl. Phys.* 4:265—268.
5. Hendricksen, H. C. (1928). Identification of citrus budding stock. *Florida Grower.* 36:(8),14—15.
6. Klein, G. (1931). Handbuch der Pflanzenanalyse. J. Springer. Wien.
7. Maerz, A. and Rea, P. M. (1930). Dictionary of colour. McGraw Hill.
8. Marloth, R. H. (1936). Notes on colorimetric tests for citrus species. *J. Pom. Hort. Sci.* 14:1—8.
9. Masters, L. C. (1948). A review of laboratory tests for the determination of citrus rootstock varieties. *Citrus Leaves.* 28:(3)21—24.
10. Webber, H. J. and Batchelor, L. D. (1943, 1948). The citrus industry, vol. I and II. Univ. Calif. press.

WATER TRANSFER FROM FRUITS TO LEAVES IN THE SHAMOUTI ORANGE TREE AND RELATED TOPICS *)

By A. ROKACH
Faculty of Agriculture, Hebrew University, Rehovot.

A. INTRODUCTION

It is a well established fact that fruits of various species lose water by osmotic leaf suction when supply runs short. With citrus fruits this phenomenon has been studied by Hodgson (5) and Bartholomew (1) in detached branches kept dry. They were able to show that the leaves remained fresh much longer on branches bearing fruit than on others. After exposure of orange branches for 24 hours, Hodgson found that leaves able to withdraw water from fruit contained 52.3% more water than those of control branches; Bartholomew, investigating branches of lemons, found the water loss of ripe fruits on leafy branches to exceed that of isolated control fruits by 25—35%. The transfer of water from immature fruits to leaves, which is highly important in connection with premature abscission during hot spells, has been studied by Coit and Hodgson (3). They found the water content of young Navel orange fruit to fall by 25—30% during hot and dry weather. This rapid loss appeared to be solely due to leaf suction.

Notwithstanding the work above cited, much remains to be learned about this internal water translocation in fruit trees. To collect additional quantitative data in respect of fruit contraction, saturation deficits, osmotic values, distance of water transport, influence of fruit age, etc. a study was therefore made on Shamouti oranges, a citrus variety not yet investigated in this respect.

B. METHODS

35 cms long branches bearing fruit were cut from the trees and kept dry in the laboratory, as a rule in a hanging position. Thus suitable conditions for the translocation of water were easily obtained. *Circumference* of fruit was measured by aid of strips of millimetre paper, after the equatorial circle had been marked by Chinese ink. Changes on fruit connected with the mother branch and on isolated controls were recorded after 24

(*) Printed with the help of a fund collected by the first graduates of the College of Agriculture, with kind permission of the Hebrew University.

hours. In other series the change after 2, 3, or 6 days was studied. *Distance of water transport* was investigated on branches with lateral ramifications leaving only fruit on the defoliated main branch and only leaves on the laterals which forked off the main at shorter or longer distances from the fruit. To decide from which part of the fruit the water is drawn, some fruits were peeled before and some after exposure. The *water content* of the peel as percentage of dry weight was determined by drying at 75°C in an electrical oven, while the growing *concentration of the solutes* in the pulp, taking place in consequence of water loss from its interior, was determined refractometrically.

The average *osmotic value* of the leaves and of very young fruits, which are composed mainly of peel, was determined by the cryoscopic method, using a microcryoscope as described by Halma (4), after extraction of the sap from the killed organs under pressure. The *water saturation deficit* of leaves given or denied the opportunity to withdraw water from fruit, was determined after the method of Stocker, with the slight modifications introduced by Oppenheimer and Mendel (8).

In order to extend knowledge on fruit water relations which is still scanty, we investigated the transpiration of young fruit using a torsion balance (max. weight 10 grams). Fruits were weighed immediately after removal from the tree and reweighed after 4 minutes' exposure at their original place of insertion. The wire used for the connection with the crochet of the balance was fixed at its other end at the stalk of the fruit in order to avoid damage to the fruit itself. To indicate the *stomatal aperture* of those fruits the infiltration method was used. *Stomatal density* was determined by microscopical counts on tangential sections taken from both ends and the equatorial portion of the fruit.

The investigations were carried out from December to February when fruit is ripe, and from April to June when it is in the first stage of its development.

C. RESULTS

1. *Fruit contraction*

The difference in fruit contraction found by others could be confirmed for the Shamouti orange in laboratory experiments carried out in December 1949 and January 1950. Two days after the branches had been cut, fruit on leafy branches lost, in one series of observations, 1.44% of their initial circumference, as against 0.77% in isolated controls. After 6 days, corresponding figures were 2.91 as against 1.47% (differences highly significant). In another series of experiments, we found no significant differences between the contraction of fruit on leafy branches as compared with that on branches defoliated but connected with a leafy lateral; in both cases contraction exceeded that in isolated control fruits by nearly

60%. Final figures recorded after 6 days were contractions of 3.68% on leafy, and 3.45% on defoliated branches, but of only 2.18% in the control. The suction of the leaves was thus found operative at a distance of a few decimetres, working unhampered by a ramification. This result was confirmed in 5 repetitions.

2. Tissue supplying water

The experiments showed that water is drawn by the leaves primarily from the peel and not from the pulp. This statement is borne out by the fact that (a) after exposure, refractometric figures for the juice from ripe fruits connected or isolated were practically identical at about 9% T.S.S. whether the fruits were attached or not, while (b) the water content of the peel differed markedly. Thus in one series of seven tests the average water content of peel from attached fruits after 2 days was 75.52% as against 76.15% in the detached controls. After 3 days it was 74.62% and 76.05% respectively, indicating considerable water loss in the attached fruit. In another series of seven tests water content of the peel after 6 days averaged 74.80% in attached, and 77.54% in detached fruit. Results were found significant in the first series at the 0.1 level only, but in the second series at the 0.01 level as well.

3. Osmotic values of leaves and fruit

In an experiment with branches bearing ripe fruit, very large differences in osmotic values were established already after a relatively short time. In sap from leaves not given the opportunity to withdraw water from fruits, figures rose in 24 hours from 16.01 to 30.34 atm., reaching after 48 hours a peak of 35.60 atm. Corresponding figures for leaves enjoying a water supply from fruits were 19.50 after 24 hours and 22.15 atm. after 48 hours.

In another series of experiments, we investigated the developmental stage at which water transfer from fruit to leaf sets in. No lag in the rise of osmotic value of leaves, as described above, was found when the fruits were just setting, i.e. at a late stage of bloom. Neither flowers nor very young fruits constituted an effective source of water supply. But the mechanism had begun to function on June 1st, when fruit had reached the size of a large olive (35x38 mms). After an initial figure of 16.81 atm., sap of leaves from fruit-bearing branches reached after 24 hours a concentration corresponding to 20.71 atm. only, as against 24.56 atm. where no fruit was present.

The cryoscopic method also showed important differences in the sap concentration of young *fruits,* the size of a small egg, when they were attached or detached. The rise was from 14.06 to 18.12 ± 0.45 atm. in attached fruit, but to only 15.3 ± 0.37 atm. in detached fruit,in both cases after 2 days. Differences were found highly significant.

4. *Water saturation deficits*

No statistically significant results were obtained in our experiment as result of wide individual fluctuations of the W.S.D. of single leaves. But there was a clear trend towards lower figures in leaves from fruit bearing branches, which after three days attained an average W.S.D. of 28.50% of the saturation water content, as against 33.26% for leaves from branches bearing no fruit.

5. *Transpiration of young fruit*

Fresh weight transpiration in the sun of fruits, the surface of which was 14—20 sq.cms., was rather low. The figures recorded were 9 mg./gm h, in the morning, 17—19 mg./gm h between 13 p.m. and 14 p.m. and 11-12 mg./gm h, between 17 and 18 p.m. Shade transpiration fluctuated between 6 and 13 mgs. throughout the day with peaks at 10:30 a.m. and 13:30 p.m. (June 1st, 1950). Sun transpiration showed a pronounced inverse relationship to humidity of the air, reaching a high peak at 13:30. No drop in transpiration intensity could be established during the first half hour after picking.

6. *Stomatal behaviour and number*

Stomata of sun and shade fruit are easily penetrated by kerosene. No decrease in the degree of infiltration was found within a few minutes. The average number of stomata near the equatorial circle was 74, near stem and stylar ends 67 per sq.mm.

D. DISCUSSION

Our results corroborate the findings of previous workers, regarding the internal transfer of water in citrus branches. The influence of leaf suction on fruit growing at a distance adds an interesting detail to the picture. Our observation that the osmotic value of the fruit pulp remains unchanged by leaf suction strongly suggests that the pulp does not participate in the water transfer. It can be still argued that this result might have been produced by parallel changes in the concentration of both solute and solvent, i.e. either by katatonosis while pure solvent was removed or else by transfer of both solvent and solute. But this does not seem likely.

Bartholomew's(1) studies suggest that the withdrawal of water from fruit by unsaturated leaves might play an important role also in the abcission of young Shamouti fruits, but this has not been investigated.

While our results regarding fruit behaviour at various developmental stages require little comment, the low transpiration figures of immature fruit warrant a short discussion. It is easily understood that a citrus fruit will have a smaller fresh weight transpiration than a leaf, since its surface-volume ratio is much smaller. Yet, a simple calculation shows that surface transpiration of leaf and fruit are similar. We have found that fruits with a

surface of 20 sq.cms. transpire in the sun in the bright hours of a June day at a rate of about 15 mg/gm h. Since such fruits weigh about 15 gms., their hourly transpiration rate will be 225 mg/20 sq.cms. On the other hand it is known from the work of Oppenheimer and Mendel(8) that the transpiration of sun leaves in June amounts to 500-800 mg/gm. h. during the same hours. According to data of Monselise(6) an average sun leaf of Shamouti has an area of about 35 sq.cms. Supposing the leaf weight to be 600 mgs. we find that one gram of such leaves covers an area of about 60 sq.cms. i.e. its area is about 3 times as large as that of the fruit referred to above. The equivalent leaf area of 20 sq.cms. will thus transpire the third part of the above figure, i.e. 167-267 mg/h. We thus arrive at very similar figures for surface transpiration of fruits and leaves in spite of widely diverging figures of fresh weight transpiration, which in the leaf is about 30 to 50 times higher. The later statement may afford a partial clue for the understanding of the fact that the fruit functions in times of water shortage as a storage organ supplying water to the leaves which lose water at a much higher rate.

The similarity of surface transpiration rates of young Shamouti fruits and leaves is remarkable since stomatal density in the fruit is much lower. Indeed we found an average number of 74 per square millimetre, while Oppenheim(6) indicates for leaves 300 and Monselise(6) 420—530. Thus a lower stomatal transpiration of the fruit which must be postulated, seems to be compensated by a higher cuticular transpiration which might indeed be considerable in this early stage of development. It should be added that both Turrell and Klotz(9) in California and Mrs Lifshitz (unpublished data) in the laboratory of the Division of Citriculture at Rehovot, found much lower figures of stomatal density in ripe oranges. This seems to be a consequence of surface growth without increase of stomatal numbers.

The present study was suggested by Dr. H.R. Oppenheimer and carried out under his guidance. His help in all phases of the work and in the preparation of this English summary of results is herewith gratefully acknowledged.

SUMMARY

The transfer of water from fruit to leaves known to occur in fruit trees and vegetables under conditions of an inner water deficit was shown to take place in the Shamouti variety.

This could be demonstrated by records of fruit contraction, and of changes of water content, osmotic values and, to a certain degree, of water saturation deficits. The suction was shown to transport water easily from a fruit on a defoliated main branch to a leafy lateral. The evidence suggests that this water is withdrawn

from the peel but not from the pulp. No measurable transfer of water takes place before the fruit attains the size of a large olive, weighing 8-10 grams.

Fresh weight transpiration of young fruit is about 40 times lower than that of leaves and stomatal density is many times lower.

REFERENCES

1. BARTHOLOMEW, E. T. (1926) Internal decline of lemons. III. Water deficit in lemon fruits caused by excessive leaf evaporation. *Am. J. Bot.* 13:102—117.
2. COIT, J. E. and HODGSON, R. W. (1917). The June drop of Washington Navel oranges. *Univ. of Calif. Bull.* 290.
3. COIT, J. E. and HODGSON, R. W. (1919). An investigation of the abnormal shedding of young fruits of the Washington Navel orange. *Calif. Univ. Publ. Agric. Sci.* 3:283—368.
4. HALMA, F. F. (1937). The cryoscopic determination of the osmotic value of Citrus leaf sap. *Gartenbauwiss.* 10:659—668.
5. HODGSON, R. W. (1917). Some abnormal water relations in citrus trees of the arid Southwest and their possible significance. *Calif. Univ. Publ. Agric. Sci.* 3:37—54.
6. MONSELISE, S. P. (1951). Some differences between sun and shade leaves of citrus trees. *Pal. J. Bot. Rehovot series* 8:99—101.
7. OPPENHEIM, J. D. (1927). Researches on the changes in the opening of the stomata which occur in different species of Citrus. *Agric. Rec. Zion Org. Inst. Agr. and Nat. Hist.* 1:9—39.
8. OPPENHEIMER, H. R. and MENDEL, K. (1939). Orange leaf transpiration under orchard conditions. I. Soil moisture high. *Pal. J. Bot. Rehovot series.* 2:1—80.
9. TURRELL, F. M. and KLOTZ, L. J. (1940). Density of stomata and oil glands and incidence of water spot in the rind of Washington Navel orange. *Bot. Gaz.* 101:862—871.

VIABILITY TESTS WITH CITRUS SEEDS

By S. P. MONSELISE
Faculty of Agriculture, Hebrew University, Rehovot

INTRODUCTION

Rapid tests to assess the germinative power of seeds are especially needed for species with slow germination processes. This is the case with citrus seeds, which emerge from soil at least two but usually more than three weeks after sowing. As citrus seeds lose their germinative power very rapidly, especially when subject to drying (1; 2), determination of their viability by quick tests is of interest. It seems that quick tests of citrus germination have not been devised. In 1950 several millions of seeds of sweet lime were imported into Israel from Cyprus and other countries in connection with plans for large scale plantings, but in many cases germination was poor. Experiments to develop a quick test of viability were then initiated. They were continued sporadically for three sowing seasons and are briefly summarized here.

I. TURBIDITY OF WATER AFTER SOAKING SEEDS

Sour orange seeds soaked in tap water for 18 hours at room temperature (in March) were found to induce different degrees of turbidity, according to methods and period of preservation. As we had no nephelometric apparatus at our disposal, we determined the transmission percentage of light at different wavelength by means of a Coleman Universal spectrophotometer, tap water serving as standard solution. Some curves obtained are shown in figure 1.

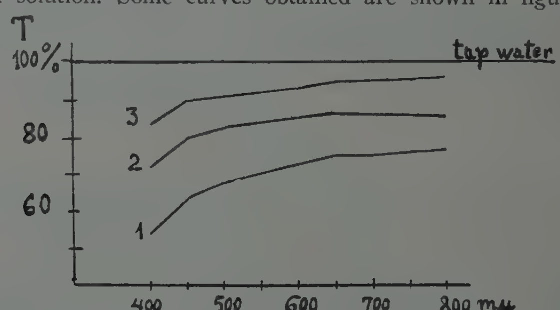


Figure 1.— Curves of light transmission obtained from tap water after soaking of citrus seeds preserved at room temperature for one day (curve 3), 12 days (curve 2) and 51 days (curve 1).

These curves are reported here to corroborate our statement, but we are aware that more refined methods must be used for the development of exact methods of seed testing based on the above principle.

Varying degrees of turbidity, detectable by the naked eye, were found also when working with selenite-indigo carmine solutions (see below).

II. CARBON DIOXIDE OUTPUT OF SEEDS

A colorimetric method proposed by WALTER (6) was used to test carbon dioxide output of seeds preserved at room temperature for different periods of time. It is based on changes in colour of a .001 N $NaHCO_3$ solution (containing a few drops of 0.10% chresol-red solution) which are produced by absorption or release of carbon dioxide. Changes in colour are compared with standard solutions adjusted to predetermined pH values. Small amounts of solution were poured into small flat containers fastened by means of iron wire to the stoppers of tightly stoppered glass jars. On the bottom of each jar 33 seeds—found to have a fresh weight of about 5 grams — were placed on moist filter paper. In parallel respiration tests seeds were presoaked for about 20 hours. All jars were kept at 36 ± 1 C°. The results of one of these tests, lasting a few hours each, are detailed here. The seeds used were of sweet lime. The control solution in a jar without seeds remained at pH 7.4 during 6h35', i. e. for the whole time of the experiment. The carbon dioxide output of seeds freshly imported from Cyprus and preserved in charcoal and that of seeds freshly extracted from local fruit was nearly the same: the pH value of the solution dropped from 7.4 to 6.9 in 2h50', in both samples. Seeds preserved at room temperature and humidity for a fortnight caused the same drop of pH only after 6h35', after which period the experiment was discontinued. Other samples, comprising seeds dried at 25 C° either (a) for a fortnight or (b) for 25 days as well as (c) seeds preserved at room temperature for 25 days and (d) seeds 10 months old, did not cause a drop of pH to figures lower than 7.2-7.1 even after 6h35'. It must be concluded that their respiration was almost nil owing to loss of viability. Although this method may prove of some use if duly standardized, better results can be expected from potentiometric measurement of pH value. Even then it remains doubtful whether results will permit an exact evaluation of germinative capacity.

III. SELENITE-INDIGO CARMINE TESTS

The use of chemicals as a substitute for germination tests is widespread although not accepted as an official method of seed testing (5). Various chemicals have been used but we do not propose to review here the vast literature dealing with this subject. We used a 1 : 1 mixture of 1% solution of Sodium-selenite and a 250

p.p.m. solution of indigo carmine both dissolved in tap water, as used earlier by others (4). Seeds stained with this mixture are killed and consequently cannot be used for subsequent germination tests. The selenite-indigo solutions stains live portions of seeds red, by reduction of selenite to red selenium, while dead portions are stained blue by the indigo.

As with other seeds, e. g. cucumber, tomato, etc. (3), seed coats of citrus must be removed for the staining of embryos. The *testa* completely prevents the staining of the interior, while the *tegmen* allows some dye to pass. However, peeling before immersion in the staining solution, involves no additional labour, as seed coats must in any case be removed to assess the results of staining. With a poisonous reagent it even appears preferable to manipulate seeds before than after soaking.

Nevertheless the necessity of peeling seeds has two important drawbacks. Firstly the testing of large samples of seeds is time consuming and troublesome; secondly—and this seems to be the main point—in practice seeds may be viable but unable to germinate owing to the presence of a more or less impervious coat. In this case it is unlikely that viability tests with peeled seed will render the same results as tests with intact seeds. Nevertheless, most workers use such tests with apparent confidence.

As a rule seeds were soaked for 24 hours in tap water and were then peeled and stained with selenite-indigo solution. As already pointed out by others (3, 4) temperature and period of staining are immaterial over very wide ranges.

In the following a brief description is given, of patterns found in citrus seeds stained with selenite-indigo solution. Both in sweet lime and sour orange, cotyledons of fresh, viable seeds are uniformly stained pale rose on the convex dorsal side, while the plane ventral side is not uniformly stained. The most outstanding feature is a periclinic line, about one millimetre wide, more or less red in colour, running along the contour of the cotyledon about 0.5 mms from its border. This line is either uninterrupted, or interrupted at the chalazal end and its colour often reaches maximum intensity at the micropylar end. The radicle, the only part of the germ which can readily be distinguished, stains mostly red, especially at its tip. When germinating seeds were stained, maximum colouring was found at growth meristems as expected, both in the radicle and plumule (figure 2). No blue stain produced by indigo carmine is found in fresh viable seeds, except on cotyledons of small undeveloped nucellar embryos and scars produced on the cotyledons by the dissecting needle while removing coats. When seeds which are partially or completely devitalized are stained, big patches of blue colour are found on cotyledons and, in extreme cases, germs are also bluish. Transverse sections of blue seeds showed that a thin peripheric layer only was blue at the chalazal end. It widened

towards the micropylar end, where a major portion of the section was uniformly stained blue.

On the whole, colour of germs seems to be more indicative of germinative power than colour of cotyledons and it was therefore correlated several times with germination percentages of comparable samples sown intact in the soil of a greenhouse. Germs were classified as red, blue or variegated.

The last mentioned category invariably comprised very few seeds. In one case, when several samples of seeds were compared at one time, the following results were obtained:—

The regression equations concerning percentage of germination in soil (G) and percentages of red and blue germs were respectively: $G = 0.704$ red $- 5.3$ and $G = 63.8 - 0.703$ blue. The coefficients of correlation (both significant at the .01 level) were:—for G and red — $r = +0.859 \pm 0.19$; for G and blue — $r = -0.864 \pm 0.19$.

From the above equations we can easily calculate that 100% of red germs theoretically corresponds to a germination percentage of only 62.5, while with about 90% blue germs, the germination is zero.

From this and other results not reported here, we may conclude that it is a condition necessary but no sufficient for normal germination of seeds that germs should assume a red colour upon staining with selenite-indigo solution. Other factors related to seed coat properties are apparently responsible for failure to germinate in many seeds with viable germs.

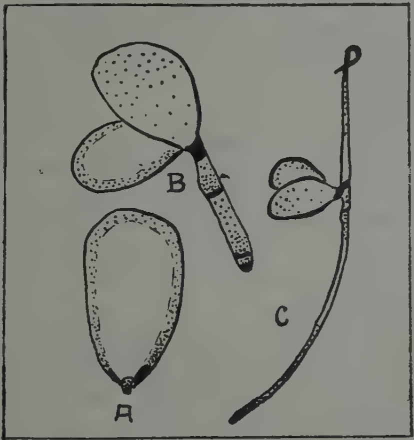


FIGURE 2. — Staining of viable citrus seeds by selenite-indigo solution. (Intensity of red colour represented by different degrees of shading.) (A) Embryo split lengthwise to show patterns at the ventral face of cotyledon and germ, (B) and (C) seeds stained at different stages of germination.

It must, moreover, be emphasized that a correlation coefficient of 0.86, while showing a high degree of correlation between staining and germination,cannot provide an adequate basis for calculating a sufficiently exact germination percentage. This may again be ascribed to interference of factors not directly linked with germ viability. Similar views are reported in a recent book (5, see page 105).

IV. GERMINATION OF PEELED SEEDS

Seeds of various citrus species were several times germinated in an incubator at 25 C° in petri dishes (20 to 30 seeds per dish) on moist blotting paper. It was found that disinfection of seeds, both intact and peeled is necessary to prevent rot. We used one-minute dips into a 1% solution of "Improved Caspan", a mercury-compound used to disinfect potato tubers, etc. Seeds soaked in tap water for 24 hours, peeled, disinfected and sown in petri dishes in the incubator germinated much more rapidly than similarly treated intact seeds (4—7 as against 21—25 days). When we observed peeled seeds of different citrus species, we found that with sour orange and Cleopatra mandarin radicles sprouted already after 4 days of incubation, while in sweet lime and rough lemon cotyledons only began to spread at this time. After seven days all above mentioned species had germinated with radicles 1 to 5 mms long. No visible changes occurred during the same period in intact seeds which began germinating only after 21 days of incubation. In another case, sweet lime seeds without coats attained 83% of their ultimate germination percentage after 8 days and their ultimate germination percentage after 15, while intact seeds attained 41% of their ultimate germination percentage after 24 and their ultimate germination percentage after 39 days.

When germination of peeled seeds in the incubator was compared with germination of intact seeds in greenhouse soil, higher percentage were always attained with peeled seeds. This seem to corroborate the views already stated in chapter III.

V. CONCLUSIONS AND SUMMARY OF RESULTS

The degree of turbidity of water after soaking seeds, and the rate of carbon dioxide output by seeds under standardized conditions have so far only theoretical interest and may lead to a practical test of viability of citrus seeds only after further study. On the other hand, the staining of seeds by selenite-indigo carmine solution and germination tests of peeled seeds in the incubator at 25 C° are suitable for practical use. They indicate to the grower the viability of citrus seeds several days or weeks before a germination test carried out in the usual way in the soil or in an incubator can be completed. The weakness of both the above methods lies in

the fact that they do not take into account the potential obstacle to germination constituted by seed coats, on obstacle which may be increased by partial drying of seeds. These tests can therefore be used to ascertain whether a sample of citrus seeds has a high or low degree of viability, but cannot give us an exact measure of its germinative power.

REFERENCES

1. Barton, Lela V. (1943) — The storage of citrus seeds. *Contrib. Boyce Thompson Inst.* 13:47—55.
2. Elze, D. L. (1949) — Germination of citrus seeds in relation to certain nursery practices. *Pal. J. Bot. Rehovot Series.* 7:69—80.
3. Plaut, M. & Gabrielit-Gelmond, Chaya (1948) — Determination of the viability of seeds of some vegetable and field crops by means of Sodium-selenite. *Proc. Int. Seed Test. Ass.* 14:190—211.
4. Plaut, M. & Reich, Dina (1944) — Testing the viability of seeds by means of Selenium salt. (in Hebrew). *Hassadeh* 26, 166—169.
5. U.S.D.A. (1952) — Manual for testing agricultural and vegetable seeds Agr. Handbook No. 30, U.S. Dept. of Agr.
6. Walter, H. (1949) — Ueber die Assimilation und Atmung der Pflanzen im Winter bei tiefen Temperaturen. *Ber. d. Bot. Ges.* 62:47—50.

THE ECOLOGICAL CHARACTER OF RUMEX ROTHSCHILDIANUS AARONSOHN

By H. R. OPPENHEIMER

Rumex rothschildianus AARONSOHN apud EVENARI is a rare endemic species first discovered in 1906 by Aaron Aaronsohn in the coastal plain of Palestine, east of Caesarea. Its 10 to 35 cm long, upright stem ends with a dense terminal spike of flowers which are green, but often run into a beautiful pink or vermilion, and lend the plant a very attractive appearance. Shape and colour of the inflorescence justify the original suggestion of the late G. BEAUVERD, keeper of the Herbarium Boissier at Geneva, to call the plant *Rumex orchidioides*. On the other hand, the shape of the perigonium which resembles a miniature group of three air-planes joined at their wing-tips and tails, reminds us of the name proposed for the species by A. EIG, viz. *R. aeroplaniformis*. This name, not having been published according to international rules, was to remain a nomen nudum, and the plant thus remains dedicated

Figure 1.—Female inflorescence (*left*) and isolated fruiting perigonia of *Rumex rothschildianus*.

to the late Baron Edmond DE ROTHSCHILD, the father of Jewish agricultural colonisation in Israel, as planned by its discoverer.

The reader interested in the morphological characters and the somewhat complicated history of the discovery and publication of this interesting annual species is referred to the detailed description by EVENARI in the "Florula Cisjordanica" (Bull. Soc. Bot. Genève, vol. 31; 1940) and to the 25 analytical drawings by J. STEIN incorporated in this joint publication by AARONSOHN, EVENARI and the present author. The present note deals exclusively with the ecological affinity of the species on which we have very scarce information only. In the labels of his herbarium, AARONSOHN failed to note the natural environment in which the plant was collected while the recent edition of the "Analytical Flora of Palestine" by EIG, ZOHARY and FEINBRUN indicates laconically: light, wet soils.

The lack of exact indications rendered the task of recovering the species rather difficult when we searched for it in the neighbourhood of Zarghanieh, the *locus classicus* where AARONSOHN had first discovered it in 1906 and then collected it again in 1916, possibly for the last time. Most lands in the neighbourhood of this ancient caravanserai or farm yard have since been covered by plantations of citrus, olives, eucalypts or jasmin. Only tracts of unstable sands and steep or rocky hills have not (or only occasionally) come under the plough to this day, and are still bearing a more or less natural vegetation cover. The growing colony of Binyamina expands more and more towards Zarghanieh from the east. These developments raised the suspicion that the plant no longer existed at this locality.

Wandering about near the ruins of Zarghanieh on April, 3 and 5, 1953, we could easily distinguish three types of light soil tracts: (1) Mobile inland dunes bearing an open vegetation dominated by *Artemisia monosperma.* (2) Stabilized sandy fields with admixture of red clay, bearing a plant cover dominated by regularily spaced shrubs of *Thymelaea hirsuta;* here, we noted *Lotus villosus* as a connecting link to the first-mentioned type of vegetation, and remarkable, sometimes pure stands of *Erodium telavivense.* (3) Kurkar hills with concretions of sandstone cropping out here and there at the surface; bushes and perennials dominating here were *Thymelaea hirsuta, Helianthemum ellipticum* and *Echium angustifolium.* In types (2) and (3) we noted numerous specimens of *Rumex bucephalophorus* and rather isolated ones of *R. occultans* Samuelsson.

Eventually, *Rumex rothschildianus* was found on the top of a kurkar hill facing the lowlands around the Crocodil River and, behind them, the mountain bearing on its top the colony of Zikhron Yaaqov. What remains of this habitat, covers less than one hectare. The plant was found in groups or scattered among rather dense herbage and interspersed bushes of *Thymelaea, Helianthemum* and

Echium, in association with the other above-mentioned species of *Rumex*. There were, at most, a few thousand flowering specimens on the top of this hill the northern and eastern slopes of which have been transformed into vegetable gardens and citrus groves. The soil was reddish sand a few decimetres deep. The plant seems to prefer flat places or gentle slopes, avoiding steep and rocky slopes facing south or south-west where *Andropogon hirtus* and *Helianthemum ellipticum* strike the eye. In addition to the already mentioned, its main associates were: *Medicago litoralis, Anthemis leucanthemifolia, Leopoldia maritima, Erodium tel-avivense* and *E. laciniatum*. The following table summarizing the analysis of four one-square-metre large sample plots, will further illustrate its phytocoenotic affinities.

TABLE

Plant sociological records of kurkar vegetation with RUMEX ROTHSCHILDIANUS *Aar. near Binyamina, Saron plain (April, 5, 1953).*

Species	I	II	III	IV
Thymelaea hirsuta	—	2.3	2.2	1.2
Helianthemum ellipticum	—	—	2.2	—
Echium angustifolium	1.2	—	—	—
Leopoldia maritima var. *dolichobotrys* Opphr.	+	2.1	1.1	+
Rumex rothschildianus Aar.	2.1	2.1	1.1	+
R. bucephalophorus	1.1	+	1.1	1.1
R. occultans Sam.	—	+	—	+
Paronychia argentea	+	—	1.1	1.1
Cutandia philistea	1.1	—	2.2	1.1
Crepis aculeata	3.2	1.1	1.1	+
Anthemis leucanthemifolia	2.1	2.1	3.2	3.2
Medicago litoralis	1.1	2.1	+	+
Cynosurus coloratus	+	—	—	—
Phleum arenarium	+	+	—	—
Hordeum murinum	+	—	—	—
Aegilops peregrina	+	—	—	+
Alopecurus utriculatus	—	—	—	+
Gagea ?dayana	—	+	+	—
Tulipa sharonensis Dinsm.	—	—	+	—
Allium sp.	—	—	+	—
Asphodelus tenuifolius	—	+	—	—
Emex spinosus	+	—	—	—
Thesium humile	—	+	—	—
Reseda orientalis	—	—	—	+
Silene colorata	—	—	—	+
Trifolium curvisepalum Täckh.	—	+	+	+
Tr. nervulosum	+	—	+	+

TABLE (continued)

Species	I	II	III	IV
Tr. dichroanthum	—	—	+	+
Lupinus angustifolium	—	—	+	—
Ornithopus compressus	—	—	+	—
Hymenocarpus circinnatus	+	—	—	—
Onobrychis crista galli	—	2.1	—	+
Erodium laciniatum	+	+	+	—
Er. tel-avivense Eig.	+	1.1	—	+
Er. ? subintegrifolium Eig	—	—	—	1.1
Euphorbia peplus	—	+	—	—
? Daucus litoralis	—	+	—	—
Anagallis coerulea	+	+	+	+
Plantago cretica	—	+	—	—
Plantago albicans	+	—	—	+
Galium ?lasianthum Eig	—	+	—	—
Scabiosa ucranica	—	—	+	—
Centaurea procurrens	+	—	—	—
Ifloga spicata	—	—	+	—
Senecio vernalis	+	+	—	—
?Picris amalecitana	—	—	+	—

Records I and II: somewhat rocky places, general coverage 90%, inclination 5°W. III: sandy, gen. coverage 70%, inclin. 10°W. IV: sandy, gen. coverage 80%, inclin. 7°W. The first cipher in the abundance, the second the dominance.

In Eig's monographical study on the vegetation of the light soil belt of the coastal plain of Palestine (this journal, Jerusalem series, vol. 1, p. 255) *Rumex rothschildianus* is not mentioned. We feel that the vegetation at the locality of our collection much resembles the subassociation *Thymus capitatus-Andropogon hirtus helianthematosum elliptici*, as defined by this author (cf. his records 10 and 14 of table 12). The association *Thymus capitatus-Andropogon hirtus* forms a connecting link between the light soil vegetation and the *Poterietalia spinosi* of the mountains. Such transitory character agrees remarkably well with the geographical position of the locality which forms the northernmost outpost of the sandy soils so widespread in the Saron plain, at their transition to the mountainous region of the Carmel. However, it should be stressed that the association in which we found *Rumex rothschildianus* resembles Eig's subassociation in a floristic rather than edaphic sense since this subassociation is supposed to be typical of still more shallow and rocky soils of a heavier type. It may, therefore, be more accurate to state that we found *R. rothschildianus*

growing in a plant society belonging to Eig's *Eragrostion bipinnatae* (*palaestinum*) but not identical with any of the three associations of this alliance defined by their author .

Summing up our observations we may state that in the locality where it was probably first discovered by Aaronsohn, *R. rothschildianus* appears a typical component of the vegetation of kurkar hills avoiding similar habitats of the light soils' series and disappearing where the soil is ploughed and cultivated. Conjectures on the reasons of its very restricted distribution and its phytogeographical character and history appear premature until further data on its occurence are collected.

Dedicated to the veteran of Israel agriculture ELIAHU KRAUSE, Director of Mikve Israel Agricultural School.

SHAMOUTI ORANGE ON VARIOUS ROOTSTOCKS AND ITS RELATIONS TO XYLOPOROSIS

By REICHERT[1]), I. YOFFE[2]), and A. BENTAL[1])

(With 3 text-figures and 3 plates)

INTRODUCTION

When the late citrus expert at the Agricultural School of Mikve Israel, S. YEDIDIAH, planned in 1928 his comprehensive experimental citrus groves, and among them his experiment of grafting Shamouti on 32 rootstocks, he had no way of knowing that these plantings would have such far-reaching importance in the clarification, years later, of the problem of Xyloporosis disease in this and other countries. He had intended chiefly to deal with general rootstock problems in order to find the most fitting stock for our Shamouti orange. This experiment was carried out upon the suggestions of the late Prof. WEBBER of Riverside, California, with whom he was in contact on all these problems (6,7). The privilege of actually carrying out this scheme fell to the second author of this article, who in 1934 planted the trees and until last year kept exact records on the state of the trees and their yield. All pertinent information, such as the kind of trees uprooted and the reasons for such action, was kept up-to-date throughout the years of the experimental period. In 1944, a report was published on the state of the trees until that date(8).

The interest focussed on Xyloporosis throughout the world, on one hand, and the resumption of citrus planting in this country, on the other hand, have revived the discussion of that old problem so much debated in this country: "What is the rootstock most suited to Shamouti?" We thus decided to examine the trees planted in the "rootstock plot" at Mikve Israel and to make observations on the influence of the different stocks grafted to Shamouti. Another reason for resuming our work was the failure of the Sour orange stock in the Tristeza-stricken countries, and its consequent exclusion from these countries as a stock for Sweet orange. This raised the question as to the suitability of Sour orange as a safe stock for Shamouti in this country. The need was felt to determine the reason for the lack of productivity of the various stocks through decline. The following observations are intended to help in the clarification of the problems outlined below.

[1]) Division of Plant Pathology, Agricultural Research Station, Rehovot.
[2]) Mikve Israel Agricultural School.

PROBLEMS

First importance was given to the problem of the factors involved in the decline of the trees in the 'rootstock plot' — whether this was due to Xyloporosis or some other disease, or whether it was caused by some lack of congeniality between the various stocks and Shamouti, the time-honoured explanation. If Xyloporosis was indeed the main cause, the degree of susceptibility of each stock to this disease would have to be determined. As so far Xyloporosis was assumed to attack Shamouti mainly on Sweet lime stock, and only in isolated instances on Sour orange (5), the behaviour of Shamouti on other rootstocks was of obvious interest.

Another question we wished to clarify was the nature of the 'Little Leaf' disease of Shamouti on Sour orange (4). This disease is characterised by small erect leaves, slightly discoloured, appearing on the crown of the tree which dies back slowly; the fruits are smaller than usual and some of them may be lop-sided in shape. Since the records of the 'rootstock plot' revealed the reasons for the uprooting of the various trees, including decline caused by 'Little Leaf' or Xyloporosis, it was pertinent to re-examine the remaining trees to determine whether they were suffering from decline, and if so, whether they showed the same symptoms as indicated in the records for the uprooted trees.

Special value may be attached to the old records in Mikve Israel with regard to another matter. With the aid of these records, and the additional examinations since made, it is possible to determine whether high-yielding, stalwart-looking trees have maintained these qualities till the last year, or whether changes occurred and decline set in. If deterioration was to reveal itself with age, this would have serious practical implications. The practice of local orange growers of taking budwood from young, vigorous looking and high-yielding trees, would then have to be discontinued and only old trees that have shown good qualities over many years should then serve as sources for budwood.

Finally, we wished to clarify the concept of "congeniality" so widely accepted in citriculture. Until now, both orchardists and investigators explained the failure of certain rootstocks toward Sweet orange as a lack of genetical affinity between the two. We, therefore, wished to ascertain whether the failure of certain Shamouti stocks in the 'rootstock plot' can be attributed to the genetical factor of affinity, or whether there is a pathogenic factor, which exists in a latent form in one or both components, and which induces the lack of congeniality, the non-productivity, and finally the decline of trees.

METHODS

The trees of the 'rootstock plot' in Mikve Israel, where the observations were carried out, were planted in 1934 with the object of finding the most suitable stock for Shamouti. The budwood was taken from a seven year old Shamouti tree grafted on Sour orange. This Shamouti tree was healthy, well-developed and high-yielding. In 1952, when we resumed our examination of the trees, we also examined the mother tree from which the budwood was taken and found that the tree was still healthy and showed no xyloporotic pitting either in the stock or scion. Only weak striations were visible on stock and scion.

The seeds for the stocks were obtained from various sources. Prof. WEBBER sent the Sweet orange varieties: Weldon, Bessie, and Madam Vinous, and Sour orange from California (Standard), Florida, and Brazil, as well as the variety Bitter-Sweet, and a willow-leaved strain of Sour orange (which will henceforth be called here 'Willow-Leaf'). He also sent, the mandarin variety Cleopatra, the Tangelo variety Sampson, a Sweet lime variety from Florida, and Rough lemons from Florida and California. Of sources in this country, seeds from an Egyptian Sour lime were received from Hadera, and seeds from an old Sweet orange tree from the nearby Arab village of Bartah (which will henceforth be called 'Bartah' variety). From Mikve Israel, seeds were obtained of local and Italian Sour orange, Sweet lime, Rough lemon, the Pummelo 'Nanas', the Duncan and McCarty verieties of grapefruit, and the Sweet orange varieties Belladi, Valencia, Pineapple and De Nice, and of *Poncirus trifoliata*. The Agricultural Research Station at Rehovot supplied seedlings of local Sour lemon. Seeds of Sweet lime and Sour orange were brought from Baghdad, Iraq, and seeds of a Syrian source of Sweet orange from Sidon, Lebanon.

The seeds were sown in 1933 in sedbeds, and in the spring of 1934 uniform sized seedlings were selected and transplanted in balls to loamy soil. In addition local Sweet lime and locally grown Rough lemon of unknown origin (which will henceforth be called "local") were transplanted to sandy soil. The soil designated here as loamy soil consisted mostly of loamy sand, with occasional layers of sand or loam. The soil termed sandy consisted in its upper layers of sand, and in its lower layers of 'Kurkar' (lime stone compacted with sand) and coarse sand. The distance between the trees in the row was 4.5 m., and between the rows 5.5 m. The varieties were not planted at random, but specifically in rows. All cultivations, fertilizer applications and other operations were applied uniformly to all the trees.

From 1934 onwards, records were kept on the development of the trees, including circumference of stock and scion, size of crown, and number as well as weight and quality of fruit. Also

recorded was the state of health of the tree, such as general condition, dieback, chlorosis of leaves, and 'Little Leaf' symptoms in foliage and fruit. The number of trees uprooted over the years and the reasons for their uprooting were also recorded. The seeds obtained from the above mentioned sources were also, for later observation, sown or grafted on local stocks in additional plots and these will be referred to as the "witness trees". In 1952 these trees were examined and the observations made are summarized in table II. Also summarized in this table are the observations made on the local trees from which seeds were taken and which also served as witness trees.

All the new examinations in the 'rootstock plot' were made in 1952. Apart from obtaining yield data, we also examined each individual tree to ascertain whether the crown suffered from dieback, leaf fall, or discoloration of the leaves etc. In addition we examined the stock and scion for signs of Xyloporosis. During these examinations we noticed in the wood of declining trees, and in some instances of outwardly healthy trees, certain symptoms other than the typical xyloporotic pitting: these were longitudinal shallow grooves or straight or wavy striations. Another pathological change noticed in the wood consisted of thin, small 'pin points' which protruded from the wood and corresponded to tiny pits on the inner side of the bark. This we termed "Inverse Xyloporosis". In the cases where the stocks showed pitting, the shallow grooves and striations were to be seen on the scion, or if the pitting occurred on the scion the grooves and striations were manifested by the stock. In certain cases both occurred together.

The results of these observations are summarized in table I. In order to make the data more readable we have concentrated the material as much as possible. Thus we have indicated in the second column the number of trees planted and in column three those which remained after uprooting. The fourth column indicates the reason for the uprooting. Of special importance seems the size of yield throughout the years. In the interest of brevity we have divided the annual yields into three periods comprising the years 1938-43, 1944-47, and 1948-51, respectively. The yield data for 1952 are given separately.

The yields were calculated in the following manner: the average yield of all trees in each variety was calculated for each year, and a mean was then calculated of the annual average yields in each period. The yields for the different varieties were expressed as percentages of the yield of the local Sour orange stock, which was considered as standard and taken as 100%.

The general state of the tree in each variety was assessed according to the condition of the majority of the trees and is described in two columns, one for the crown as a whole and one

for the foliage. The crown is described as vigorous, good, fair, or poorly developed. The foliage is described as profuse, normal, declining, or poor. The number of trees showing lop-sided fruit, pitting in stock and scion, and striations in stock and scion, is also indicated in the table.

To give numerical expression to some of our observations, estimates were made of the decline of Shamouti on Sweet orange stocks in the following way: The general condition of the foliage of all trees of the same variety was assigned 0 marks when profuse, 3 marks when normal, 6 marks when declining, and 12 marks when poor. The marks were then multiplied by the number of the trees. To the resulting sum we added the following marks for the pathological symptoms found in each individual tree: 2 marks for 'Little Leaf', 2 marks for pitting in the stock, 2 marks for pitting in the scion, 1 mark for striations in the stock, and 1 mark for striations in the scion. The result of this addition was divided by the number of trees in each variety to yield the 'decline rating'. With the foregoing method of estimation the highest possible decline rating per tree is:

	12	(for condition of the foliage)
plus	8	(aggregate of marks for all pathological symptoms)
to total	20.	

This theoretical maximum was taken as 100% and the decline ratings actually found were expressed as its percentage to obtain the 'percentage decline'. Although this method is highly arbitrary, the results of such estimation may help to clarify our observations of Shamouti on Sweet orange stocks (text-fig. 3).

OBSERVATIONS

The Rootstock Plot

We stress that the data presented in Table I to summarize our observations, are not intended to establish final facts as to the qualities of the rootstocks, but only indicate the condition as seen in 1952, nineteen years after planting. This period is sufficient to permit of accurate and practical conclusions as to the general qualities of the rootstocks, and in particular as to their degree of sensitivity to diseases. It should be emphasized, however, that in years to come changes may still set in among the trees, even in stocks that have so far shown normal growth.

SOUR ORANGES.— The group of Sour oranges consisted of eight varieties from various countries, including Bitter-Sweet and the Sour orange strain Willow Leaf. A great number of these deteriorated during the first years owing to 'Little Leaf' decline and were uprooted. The surviving trees showed great differences in the size of their yield and in their tolerance to decline. It is here possible to distinguish between three types.

TA

Behaviour of Shamouti on 32 root
(“Roc

Rootstock	Number of trees: planted	surviving	Reason for uprooting	% Mean 1938—43	1
				58.6 kg.—	155
1. Sour orange, Local	34	25	Little Leaf	100%	
2. ” from Brazil	6	5	” ”	80.4	
3. ” ” Florida	9	7	” ”	82.1	
4. ” ” California	9	7	” ”	99.0	
5. ” ” Baghdad	8	7	” ”	83.6	
6. ” ” Italy	6	5	” ”	72.2	
7. ” ‘Willow Leaf’	8	7	” ”	74.4	
8. ” ‘Bitter Sweet’	5	4	” ”	66.2	
9. Pummelo ‘Nanas’	6	3	” ”	87.0	
10. Grapefruit ‘Duncan’	6	3	” ”	92.0	
11. Grapefruit ‘McCarty’	6	3	” ”	106.2	
12. Poncirus trifoliata	5	3	” ” [8]	65.0	
13. Mandarin ‘Cleopatra’	5	5	—	113.6	
14. Tangelo ‘Sampson’ (planted in 1935)	3	3	—	—	
15. Sour Lemon, Local	5	5	—	89.0	
16. Sweet Lime, Local	34	32	Xyloporosis		
a) inarched with Sour orange[1]	8	8	—	90.6	
b) ” Rough lemon[2]	8	8	—	102.4	
c) ” Sour lime[3]	8	8	—	107.6	
d) ” Sweet lime[4]	8	7	Xyloporosis	90.4	
17. Sweet Lime, Local (in sandy soil)	4	4	—	94.8	
18. Sweet Lime from Florida[5] (inarched with Rough lemon)	5	4	Xyloporosis	76.1	
19. Sweet Lime from Baghdad[6] (inarched with Rough lemon)	5	4	Xyloporosis	71.8	
20. Rough Lemon from Florida	5	4	Little Leaf	105.4	
21. ” ” ” California	5	4	” ”	102.9	
22. ” ” Local (in sandy soil)	4	4	—	116.5	
23. Egyptian Sour Lime	7	7	—	118.6	
24. Sweet Orange Belladi	8	3	Little Leaf	104.0	
25. ” ” Bartah	9	5	” ”	126.4	
26. ” ” Valencia	6	4	” ”	93.1	
27. ” ” Syrian	6	4	” ”	94.7	
28. ” ” Pineapple	7	4	” ”	87.8	
29. ” ” Weldon	4	3	[8]	132.7	
30. ” ” Mad. Vinous	4	4	—	116.2	
31. ” ” Bessie	5	2	Little Leaf	102.4	
32. ” ” De Nice	7	4	” ”	107.6	

[1] No inarches contracted pitting.
[2] 3 ” ” ”
[3] 4 ” ” ”
[4] All ” ” ”
[5] 1 ” ” ”
[6] 3 ” ” ”

in Mikve Israel in loamy soil in 1934.

tree		Condition of		Number of trees showing:				
51	1952	crown	foliage	lop-sided fruits	pitting on stock	pitting on scion	striations on stock	striations on scion
.—	154 kg.—							
)%	100%	good	profuse	1	0	0	19	13
.6	7.1	”	declining	0	1	1	1	3
.1	35.9	”	”	1	0	0	7	5
.8	23.3	”	”	4	3	2	4	5
.3	113.6	”	profuse	2	0	0	7	6
.6	86.3	”	normal	0	0	0	4	5
.0	72.0	”	”	0	0	0	7	7
.4	78.5	”	”	3	4	0	0	4
.9	111.6	”	”	1	0	0	0	1
.3	50.6	fair	declining	0	2	1	1	2
.0	76.6	good	normal	0	2	0	0	3
.2	20.7	poor	poor	1	3	1	0	0 + 1 I.X[7]
.4	28.0	good	declining	1	0	1	1	1
.2	80.0	fair	normal	1	0	0	1	3
.7	8.7	poor	poor	0	3	2	2 + 2 I.X[7]	3 + 2 I.X[7]
.5	92.8	good	normal	0	8	0	0	4
.9	51.9	fair	declining	0	8	3	0	3 + 2 I.X
.2	83.7	good	normal	0	8	4	0	4
.0	6.4	poor	poor	0	7	7+2 I.X.[7]	0	0
.8	77.0	fair	normal	0	4	2	0	2
.3	31.1	fair	poor	0	5	0	0	1
.8	31.7	fair	poor	0	4	0	0	4 + 1 I.X[7]
.3	61.7	fair	poor	2	3	2	0	0 + 1 I.X[7]
.9	33.7	”	poor	1	3	2	1	1 + 1 I.X[7]
.1	88.3	good	poor	2	2	1	2	2
.7	78.5	good	declining	2	5	1	1	5
.0	94.1	”	normal	0	1	0	2	3
.2	88.9	”	poor	1	1	0	4	4
.5	147.4	vigorous	profuse	0	1	1	2	3
.9	140.2	good	poor	1	1	2	2+1 I.X.[7]	2
.0	101.9	”	normal	2	1	1	2	3
.8	131.8	vigorous	declining	1	2	2	1	1
.1	105.8	good	”	1	2	1	1	2
.1	111.7	”	normal	1	1	1	1	1
.3	92.2	”	declining	1	0	0	4	4

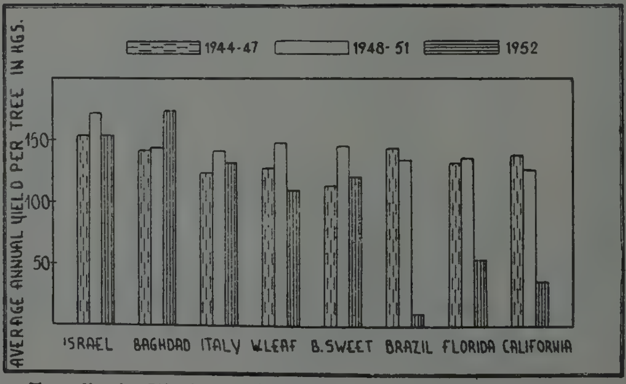
= Inverse Xyloporosis
ree each of P. trifoliata and Weldon were
oted because the graft failed to take.

The first and best type embraces our local Sour orange (Khoushkhash), and the Sour orange from Baghdad. Both demonstrated, through all the years, good crown development, prolific foliage, and rootstocks that were unaffected by xyloporotic pitting (only in the scions were striations and shallow grooves evident, a form which seems to us to present an initial and not strongly virulent stage of Xyloporosis). Their yields corresponded with the fine condition of the trees.

The second type was intermediate in its qualities. It comprised the Italian, the Bitter-Sweet, and the Willow-Leaf strain of Sour orange from California. Fair yields were characteristic of this group, but to a lesser extent than with the first group. The size of the crown in all these trees was invariably large and their foliage normal. All three varieties manifested striations and grooves on the scion, and, in addition, Bitter-Sweet showed typical pitting in the rootstock.

The third type was the most susceptible. It consisted of the Sour oranges from Florida, Brazil, and California. All of them made a good start at the beginning and developed a strong crown, but during the last year they began to show dieback and decline. Small, yellow, cup-like leaves were evident and true xyloporotic pitting was found on the rootstocks of three of the Californian (standard) Sour oranges and in two of their scions. In one Brazilian tree pitting was likewise manifested by both stock and scion. Striations and grooves were seen in all these cases in both scion and stock. In all the trees from these three sources in this category there was a sudden drop in yield in 1952, while yields in 1951 were still normal (text-fig. 1; pl. I, figs. 1—4).

ROUGH LEMON.— Of the three varieties (from Florida, California and Israel), the local variety, which had been planted



Text-fig. 1. Yields of Shamouti on Sour orange varieties.

in sandy soil, excelled in contrast to the other two, which were planted in loamy soil. The two foreign varieties each lost a tree through decline whilst all the local trees survived. All the varieties reached their peak yield by the fifth year, but in the following years those on Californian and Floridan rootstocks dropped to half their former yield, whereas the local source maintained, more or less uniformly, high yields up to and including 1952. This state of the yields was in conformity with the state of the trees. The crown of the local variety was well developed and the foliage poor, as compared with the poorly developed crown and foliage of the trees from the other two sources. In all three varieties many trees showed xyloporotic pitting in scion and stock. In the foreign varieties pin points, or Inverse Xyloporosis, were also to be seen in some instances. (Pl. III, fig. 3).

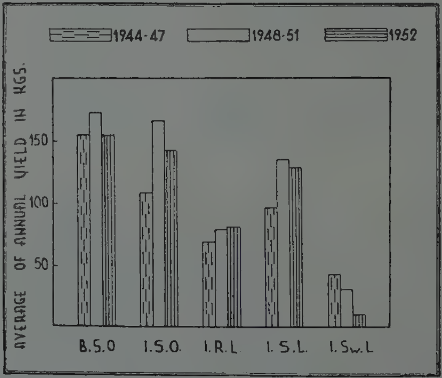
Since the soil in which the local Rough lemon variety was planted was lighter than that in which the foreign varieties were planted, no conclusions as regards their respective susceptibilities to decline are possible. It seems that loamy soil is not suitable for Rough lemon, and it is reasonable to assume that local varieties if planted in loamy soil, would have given results as poor as those shown by the foreign varieties planted in such loam. This opinion is supported by the fact that the local Rough lemon when used for inarching xyloporotic Sweet lime in loamy soil did not give good results, whereas other varieties such as Sour orange and Sour lime succeeded (cf. below) (Text-fig. 2).

Sour lime.— In the 'rootstock plot' there was but one source of Sour lime, namely the Egyptian. All of the seven trees planted survived. In the first years, fast growing and very high yields, which surpassed even our Sour orange, were recorded. The crowns were very well developed, but they began to show signs of decline during the later years. Examination showed that five of the trees had typical Xyloporosis in the rootstock and in addition one of the trees manifested Xyloporosis in the scion as well. Apart from this, striations were also present.

Sweet lime.— There were three sources of Sweet lime — one from Baghdad, one from Florida, and one local. The foreign varieties and most trees of the local variety were planted in loamy soil, while a few trees of the local Sweet lime were planted in sandy soil. The trees of the local variety in the loamy soil showed serious decline after two to three years and two out of 34 died. In 1938 it was decided to save all the surviving trees by inarching. The surviving trees (local variety) were inarched with four varieties: Sour orange, Rough lemon, Egyptian Sour lime, and local Sweet lime. The two foreign sources were inarched only with local Rough lemon. Examination in 1952 showed the Sweet lime stock to be in total decline and its function taken over entirely by the inarches.

The Sour orange ranked as the best inarch, the trees inarched by it showing good development and yields that rivalled those of Shamouti budded directly to Sour orange. The second best inarch was Egyptian Sour lime, and the results resembled Shamouti budded directly on Egyptian Sour lime. In sharp contrast, trees inarched with Rough lemon showed a considerable drop in yield, viz. 80 kgs. as against the 140 kgs. given by the trees inarched with Sour orange. The yield decline began in the 1944-47 period, simultaneously with that in Shamouti budded directly to Rough lemon. The Sweet lime inarch was a total failure. All the trees declined and the yield dropped to an average of only 10 kgs. per tree. Once again the drop began in the 1944-47 period. The Rough lemon inarches on the foreign Sweet lime were also of little success, especially in the case of the Californian variety. It is to be emphasized, however, that all the inarches, except of Sour orange, showed xyloporotic pitting. On the other hand, the Shamouti grafted to Sweet lime in sandy soil gave fair yields and fair crown development in spite of xyloporotic symptoms in the rootstock. (Text-fig. 2; pl. I, fig. 5).

Sour lemon.— There was only one variety of Sour lemon of local origin, which, during the first period of 1938-43, yielded reasonably well, viz. 89% of the Sour orange yield. However, in the succeeding four year period there occurred a sudden drop to 37%, this decrease continuing until in the last year of the examination (1952) the yield reached only 9%. Detailed examination revealed a continuous decline, die-back of the crown, and xyloporotic pitting in the stocks of three trees. Two of the scions were found to be affected as well, and on one scion pin-points or Inverse Xyloporosis were noticeable.



Text-fig. 2. Yields of Shamouti on local Sweet lime affected by Xyloporosis and inarched with: Sour orange (I.S.O.), Rough lemon (I.R.L.), Sour lime (I.S.L.) and Sweet lime (I.Sw.L.), as compared with yield of Shamouti budded on Sour orange (B.S.O.).

GRAPEFRUIT.— The two grapefruit varieties were Duncan and McCarty. Of the six trees originally planted, of each variety only three survived, three being discarded because of 'Little Leaf' decline. The surviving trees behaved in different fashions. The McCarty variety developed a large crown whilst the Duncan variety developed but a mediocre crown. During the first ten years, both varieties gave more or less equal yields, but in the following years the yield of the Duncan started to show a decrease. On the other hand the McCarty variety maintained a high yield throughout. An examination of stems revealed that two of the three rootstocks in each variety were affected by xyloporotic pitting. In addition, one scion of the Duncan also showed pitting. The Duncan variety showed striations on the stock and also on the scion whereas only the scion of the McCarty variety showed striation. It would appear that the McCarty variety exhibits a greater tolerance to xyloporotic pitting than the Duncan (pl. II, fig. 4).

"NANAS" PUMMELO.— Of the six trees originally planted only three remained, three being uprooted on account of 'Little Leaf' decline. The three that remained showed equal development during the experimental period. In the last year of the examination, their yields were approximately equal but slightly lower than those of the Sour orange. The state of the foliage was fairly good, and there was no sign of any pitting on the stock. On one of the scions, striations were visible.

MANDARIN.— The only variety was Cleopatra. All the planted trees survived. One of them was heavily afflicted with gummosis, and the other four showed some decline. During the first six years (1938-43) Cleopatra gave very good results which were more or less maintained until 1951. But in 1952 a sudden and steep drop occurred (to 28%). Moreover in spite of the good crown development some signs of initial die-back became noticeable on four of the trees. Pitting appeared on the scions of one of the trees and on another tree striation was observed on both stock and scion. The sudden yield drop in 1952 agrees with the above change in the condition of these trees.

TANGELO.— The single variety, Sampson, was planted a year later than the other rootstocks. Crown development was mediocre from the beginning, and the yield during the eight years from 1953 to 1951 was low. However, in 1952 the yield was suddenly and unexpectedly doubled. The three rootstocks of the three trees did not show any pitting and only striations were noticed in the scion. Special interest will attach to observations on this variety in the future.

PONCIRUS TRIFOLIATA.— This species was a great disappointment as a rootstock. During the first six years the yield averaged 65% but during the following years it decreased to 21% in

the last year. The general state of the trees corresponded to the poor yields. The trees were small, and the crown and foliage poor and showed decline. All the stocks as well as some of the scions showed pitting. In addition the scion of one of the trees showed pin-points or Inverse Xyloporosis. The poor state of the trees grafted to *P. trifoliata,* and the fact that of the five planted two were uprooted, indicate the undesirability of *P. trifoliata* as a rootstock.

Sweet orange.— There were nine varieties of Sweet orange in the 'rootstock plot', three being of local orange and six derived from foreign sources. Some trees of almost each variety were uprooted on account of decline, the greatest number in the Belladi and Bartah varieties. All the trees belonging to the Madam Vinous variety survived. The one common factor in all the Sweet orange varieties was the good and uniform development of the crown. In two varieties, Valencia and Weldon, the crown was especially profuse. The yields of all the varieties were equal during most of the years and equalled those of the Sour orange. In 1952 some of the varieties even exceeded those of the Sour orange: thus Valencia in this year gave a yield of 227 kgs., the Syrian Sweet orange 216 kgs., and the Weldon 203 kgs., as compared with 154 kgs. per tree for Sour orange. However, in spite of the high yields, examinations in 1952 revealed decline of foliage in most varieties. Only the Valencia maintained the well developed foliage of its three trees, although one of the trees showed some die-back. Some pitting and striations was noticeable in one or two trees of all the varieties. The De Nice variety was free from pitting but not from striation. The Syrian variety, in addition to the usual pitting, also showed pin-points or Inverse Xyloporosis on one of the stocks. Further observations on the different varieties of Sweet orange rootstocks will indicate whether their susceptibility to Xyloporosis will also involve further decline in the tree and yield. (Text-fig. 3; pl. II, fig. 3).

The Witness Trees

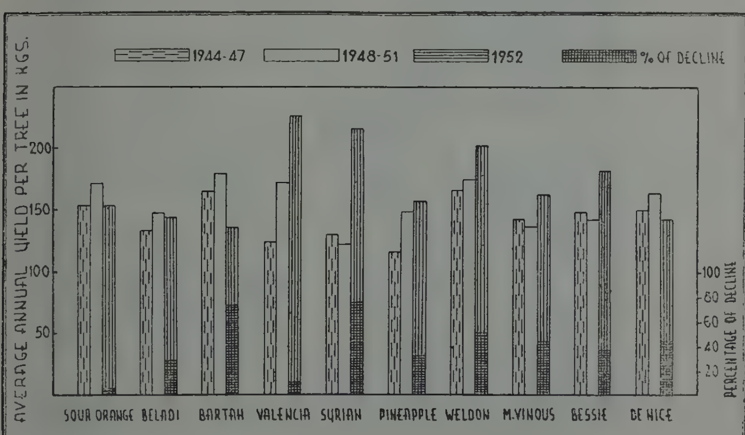
As already mentioned, some of the seeds derived from foreign sources were also sown separately in a 'witness tree plot', so that the resultant trees could be observed. In addition, some of the seedlings from these seeds were budded to local stocks to facilitate examination of their behaviour as scions. Observations were also carried out on the mother-trees of the local seeds used in the rootstock plot. Although the observations carried out in the above three instances were confined to single specimens, they nevertheless supplement our observations with regard to Xyloporosis susceptibility of the 32 types of trees of the 'rootstock plot'.

Reviewing the results presented in table II, it will be seen that the behaviour of the seedlings in the 'witness tree plot' more

or less conforms with the behaviour of those same varieties when used as stocks in the 'rootstock plot'.

The first type in the Sour orange group (local and Baghdad varieties) showed fairly good development as seedlings, although the foliage of the Baghdad variety in the seedling stage was not as profuse as in the 'rootstock plot'. However, the general health of the Baghdad variety among the 'witness trees' is not inferior to that of this variety in the 'rootstock plot'. Of the second type in the Sour orange group (Italian, Willow Leaf, and Bitter Sweet varieties), when grown as seedlings, the Willow Leaf variety maintained its good development and resistance to Xyloporosis. The development of the Bitter Sweet variety among the 'witness trees' was inferior to that in the 'rootstock plot'; the general development of the Italian variety was similar in both cases except that among the 'witness trees' some pitting was observed although there was no appreciable damage. The Sour lemon seedlings showed poor growth as 'witness trees' and in the 'rootstock plot'. The single Sweet orange variety grown as a seedling (Belladi) started with a vigorous crown but later declined more pronouncedly than in the 'rootstock plot'.

The observations on the seedlings budded to local stocks among the 'witness trees' were also interesting. Their behaviour resembled that of the same varieties used as stocks in the 'rootstock plot'. The Baghdad variety budded to Sour orange produced a good crown and profuse foliage and thus, once again, proved itself a first class type of Sour orange. The second type of Sour orange (Italian, Bitter Sweet, and Willow Leaf), when budded, showed



Text-fig. 3. Yields and estimated percentage of decline of Shamouti on various Sweet orange stocks as compared with Shamouti on Sour orange.

TABLE

Observations on the general development and

Variety	Mode & date of propagation (S.O. = Sour orange, S.L. = Sweet lime R.L. = Rough lemon)	
1. Sour orange, local	seedling	1928
2. " from Brazil	budded on local S.O.	1934
3. " " Florida	" " " "	"
4. " " California	" " " "	"
5. " " Baghdad	seedling	1935
" " "	budded on local S.O.	1934
6. " " Italy	seedling	1935
" " "	budded on local S.O.	1934
7. " Willow Leaf	seedling	1935
" " "	budded on local S.O.	1934
8. " Bitter Sweet	seedling	1935
" " "	budded on local S.O.	1934
9. Pummelo 'Nanas'	" " " "	1928
10. Grapefruit 'Duncan'	" " " "	"
11. Grapefruit 'McCarty'	" " " "	"
12. Poncirus trifoliata	seedling	1930
13. Mandarin 'Cleopatra'	budded on local S.L.	1935
14. Tangelo 'Sampson'	budded on local S.O.	1930
15. Sour lemon, local	seedling	1935
16. Sweet lime, local	seedling	1928
17. Sweet lime, local	"	"
18. " from Florida	budded on local S.L.	1934
19. " " Baghdad	" " " "	1933
20. Rough lemon from Florida	not propagated	
21. " " " California	not propagated	
22. " " local	seedling	1929
23. Egyptian Sour lime	budded ol local S.L.	1932
24. Sweet orange: Belladi	seedling	1930
25. " Bartah	budded on local S.O.	1931
26. " Valencia	" " " "	1928
27. " Syrian	budded on local S.L.	1934
28. " Pineapple	budded on local S.O.	1928
29. " Veldon	budded on local S.O.	1934
30. " Mad. Vinous	" " " "	"
31. " Bessie	" " " "	"
32. " De Nice	budded on local S.L.	1928

II
decline symptoms of the "Witness Trees".

Condition of		Decline symptoms		
crown	foliage	trunk	stock	scion
good	profuse	grooves	——	——
"	declining	——	grooves	grooves
collapsed under weight of snow				
good	poor	——	pits	grooves
"	almost normal	grooves	——	——
"	profuse	——	grooves	grooves
"	normal	pits	——	——
"	"	——	grooves	grooves
"	"	striations	——	——
"	"	——	grooves	striations
fair	poor	grooves	——	——
good	almost normal	——	grooves	pits
"	normal	——	striations	striations
poor	poor	——	smooth	pits
good	normal	——	smooth	striations
"	"	pits	——	——
fair	poor	——	pits	smooth
good	profuse	——	grooves	grooves
"	poor	pits	——	——
"	normal	pits	——	——
"	"	"	——	——
fair	poor	——	pits	pits
"	declining	——	pits	pits
good	declining	pits	——	——
died of frost in 1942				
vigorous	declining	grooves	——	——
good	"	——	grooves	grooves
"	normal	——	smooth	smooth
"	declining	——	pits	pits
"	normal	——	striations	striations
"	declining	——	grooves	grooves
"	"	——	pits	grooves
"	poor	——	grooves	pits
fair	"	——	pits	smooth

medium development. The Willow Leaf crown here was somewhat weaker than that produced by Willow Leaf as a stock in the 'rootstock plot', but no pitting was apparent in the tree. Bitter Sweet variety, when budded, revealed a development as weak as in the 'rootstock plot'.

In the grapefruit-pummelo group budded to Sour orange, the "Nanas" pummelo and McCarty grapefruit showed the same good development as 'witness trees' as in the 'rootstock plot'. The Duncan grapefruit developed poorly both as a scion among the 'witness trees' and as a stock in the 'rootstock plot'.

The behaviour of the Mandarin-Tangelo group was also similar in the two plots. The Cleopatra budded to Sweet lime made a fair start in its crown development but produced a degenerated foliage and its Sweet lime stock showed pitting. A similar situation was manifested by Cleopatra in the 'rootstock plot'. The Sampson tangelo when budded to Sour orange developed a good crown and profuse foliage, and no pitting was noticeable. The behaviour of the Sampson tangelo in the 'rootstock plot' is not clear, as previously mentioned.

Sweet limes budded to local stocks manifested similar features both as 'witness trees' and in the 'rootstock plot'. Sweet limes from Florida and Baghdad gave poor trees which showed pitting on both stock and scion, similar to their behaviour in the 'rootstock plot'.

The Sweet orange group among the 'witness trees' was chiefly budded to Sour orange, two varieties being budded to Sweet lime. These two varieties (Syrian and De Nice) were a complete failure: they declined and showed pitting either on stock or scion. These two varieties also showed a similar behaviour in the 'rootstock plot' during the last year of observation. The other four Sweet orange varieties budded to Sour orange developed a good crown but later on, with the exception of Valencia, they showed severe decline; two varieties manifested pitting as well. The Valencia maintained good to normal development and the stock and scion remained perfectly smooth without any form of pitting or grooving, exactly as the Valencia in the 'rootstock plot'.

DISCUSSION

Reviewing the results detailed above we may come to the following conclusions:

Firstly, we may conclude that the chief factor in the selection of a rootstock for Shamouti is not the congeniality or productivity of the rootstock, but its relationship to Xyloporosis and 'Little Leaf'. The productivity and compatibility of the rootstock are only functions of its susceptibility to this malady. Up till now insufficient attention has been devoted to this aspect of the rootstock problem even although the disease has been present in this country for a

number of years. Of the external factors, only the type of soil has some bearing on rootstock performance in relation to the disease.

A second important conclusion is that the use of Sweet lime as a rootstock to Shamouti is undesirable in loamy soil. Such combinations are condemned to decline from the beginning, and their only chance of survival is by the use of Sour orange, or to a lesser degree of Sour lime, as an inarch. The inarch assumes all the functions of the original deteriorating stock and transfers to the scion all the qualities of the stock in the same manner as if it were the original stock. This is also the reason why the Sweet lime inarch is unable to rectify the diseased condition of the Shamouti, since the Sweet lime itself is heavily affected by Xyloporosis when serving as a rootstock. It also became clear that the Sweet lime can serve as a stock to Shamouti in light soils, since Xyloporosis does not develop rapidly under such conditions. From table I we see that Shamouti budded to Sweet lime in sandy soil gave yields which, although lower than those given by Shamouti budded to Sour orange in loamy soil, are nevertheless reasonable.

The Egyptian Sour lime showed fair results during the years of the experimental period. Only in the last year signs of decline appeared in the crown and xyloporotic symptoms on the stem. However, the yields were only slightly affected. Sour lemon was a total failure, it showed a heavy decline in the top and xyloporotic symptoms on most of the stocks and scions. One of the scions was also afflicted by Inverse Xyloporosis, and a general decrease in yield was observed after five years. The 1952 yields were almost negligible. (Table I, No. 15).

On the other hand, the local Sour orange proved itself well. It is to be noted, however, that during the early years of the experiment nine Sour orange trees succumbed to 'Little Leaf' decline and had to be uprooted. Only the 25 surviving trees showed good development and gave satisfactory yields. In addition to the local Sour orange, the Sour orange brought from Baghdad was also successful. By contrast, the Sour orange sources from Brazil, Florida and California did not succeed as well, showing in 1952 a decline of the tree-tops, a decrease in yield, and xyloporotic pitting and striations on the stock and also on the scion of some of the trees. The Italian Sour orange, and the Bitter-Sweet and Willow-Leaf varieties from California were not as successful as the local and Baghdad Sour oranges, but were nevertheless more successful than the usual American Sour orange stocks. The additional observations made on the 'witness trees' of Sour orange agree on the whole with the observations in the 'rootstock plot'.

Our observations have also indicated that the Cleopatra mandarin, which abroad has shown a certain tolerance to Tristeza, failed in the last year in this country. In 1952 there was a strong

drop in the yield (from 78% to 28%), signs of decline were manifested in the crown, and the scion of one of the trees showed Xyloporosis. When grafted on Sweet lime (table II, No. 13) it manifested a much stronger decline. The Duncan grapefruit was not particularly successful. In spite of its early success during the first ten years, yields subsequently started to decrease, and the top to decline, and xyloporotic pitting became noticeable on the stock and on the scion. The same variety when grafted on Sour orange (table II, No. 10) was also very poor. The results given by the Sampson tangelo were not clear. During most of the experimental period the yields were low, but in the last year there was a very definite improvement. The general state of the tree was also fair, the stock did not show any pitting and only some of the scions were striated. When grafted on Sour orange (table II, No. 14) the tangelo was very successful. It will thus be necessary to reserve judgment on this variety pending further observations. Fair results were obtained with the McCarty grapefruit and still better results with the 'Nanas' pummelo in the 'rootstock plot', and as 'witness trees'. But the quality of Shamouti fruit on pummelo is not of the best. *P. trifoliata* showed decline and pitting in the 'rootstock plot' and as 'witness trees'.

Especially good results were originally obtained from all the 9 varieties of Sweet orange. During all the years they gave high yields, and it was only in the last year that signs of decline were noticed. This was manifested in the Syrian and De Nice varieties in the 'rootstock plot' and when grafted on Sweet lime (table II, Nos. 27, 32). The other six varieties when used as stocks, grown as seedlings, or grafted on Sour orange showed decline with or without pitting. The Valencia excelled in the 'rootstock plot' and among the 'witness trees' by maintaining the good state and high yield of most of its trees even in the last year. The Valencia is thus a good stock for Shamouti on loamy soil in our country. Nevertheless it will be worthwhile to continue the observations on this and the other Sweet orange varieties.

Yet another important conclusion can be drawn from our observations. It would appear that there is no justification for choosing the budwood from young trees since Xyloporosis need not necessarily manifest itself in the young trees, but may be latent and develop later on. As seen from table I, the decline usually sets in after the 9th year and occasionally even later, as in the case of the Sweet oranges where the die-back set in during the 17th year.

From our observations in the 'rootstock plot' (table I) and among the 'witness trees' (table II), something may evidently be learnt as to the relationship between Xyloporosis and 'Little Leaf', a problem which has been raised by us elsewhere (3). In our first treatise on these two diseases (4,5) we thought that they were

unrelated since Xyloporosis appears chiefly on Shamouti grafted to Sweet lime whilst 'Little Leaf' appears on Shamouti budded to Sour orange. Our observations, as seen from table I, indicate the reasons why certain trees from each variety were uprooted, this reason being that most of the trees were afflicted by 'Little Leaf' (21 out of 24 varieties). It is to be noted that we have no observations on the possible occurrence of Xyloporosis on these trees since at the time of this examination (1935—36) no attention was paid to possible xyloporotic symptoms on varieties other than Sweet lime. However since from our recent observations (table I), as well as from our general experience in citrus groves, we are of the opinion that 'Little Leaf' is in many cases accompanied by Xyloporosis, we may assume that in the early years of the experiment those trees afflicted by 'Little Leaf' were also affected by Xyloporosis. In the surviving trees a new decline set in — and there is every reason for assuming this to be a continuation of the old decline — which examinations revealed to be Xyloporosis. In addition there also appeared in these trees the characteristic feature of 'Little Leaf', i.e. the occurrence of a certain number of lop-sided fruits, as is seen from table I. Out of 32 varieties, 20 were afflicted by 'Little Leaf'. 14 of these diseased varieties showed pronounced xyloporotic pitting and the remaining 6 varieties revealed only initial stages of Xyloporosis like grooves, striations or pin-points. Thus we believe we are justified in concluding that Xyloporosis was the chief reason for the uprooting of the trees declining early, and that identity seems to exist between Xyloporosis and 'Little Leaf'. As to the question why in our first study on 'Little Leaf' of Shamouti on Sour orange (4) no xyloporotic pitting — now considered by us to be identical with 'Little Leaf' — was noticed, one may reply that pronounced pitting is very rarely manifested on Sour orange (5), and at that time no attention was paid to the grooves and striations now considered by us to be initial stages of Xyloporosis. Among the Sour orange varieties in the 'rootstock plot' (table I) pitting was observed only on the Californian and Brazilian varieties, whereas the other stock varieties revealed only grooves and striations. On the Californian variety, which showed heavy decline, pronounced symptoms of lop-sided fruits were found. Pitting was also revealed on local Sour orange among the 'witness trees' when used as stock to the Californian Sour orange variety. The Italian Sour orange showed pitting when grown as seedling ('witness trees'). The Bitter Sweet revealed pitting when grown as stock, and when grafted on local Sour orange as 'witness tree'. It is interesting to note that even the Tristeza disease of Sweet orange, recently shown to be characterized by pitting on various stocks, according to certain authors, less frequently develops this pitting on Sour orange — the most susceptible stock to this disease (2). Xyloporosis is manifested on Sour orange chiefly by a decline of the top and by shallow grooves or striations. It must also

be emphasized that Xyloporosis on Sweet lime does not always induce lop-sided fruits but sometimes merely the general form of decline, as one may see from our examination in 1952 (Table I). On the other hand many cases were observed by us, at Mikve Israel, of Shamouti on Sweet lime suffering from Xyloporosis and bearing characteristic lop-sided fruits (pl. III, fig. 4).

Our observations have also shown something as to the morphological forms of stem pitting. We may distinguish between three types of anatomical changes in the wood of afflicted trees. The first form is the usual pitting as described by us years ago (5); this as we have more recently seen, appears also on the scion, and sometimes on the branches and roots in addition to the stock as believed originally. The second form consists of longitudinal grooves or striations which may be straight or wavy. These appear on the stock, scion, branches, roots, and occasionally on both stock and scion at the same time. It is our opinion that these symptoms are first signs of Xyloporosis. In healthy trees the wood is entirely smooth. Certain striations and grooves are also observed in the Tristeza disease. The third form is called by us pin-points, or Inverse Xyloporosis. In this form the very small projecting pin-points are on the wood and the corresponding pits are to be observed on the inner part of the bark. The affected parts are brown and sometimes impregnated with gum. Such minor protuberances were noticed on *P. trifoliata,* on Sour lemon, on foreign Rough lemons, and on Syrian Sweet orange. This pathological symptom is quite new and specific. The anatomical structure of the last two forms have still to be investigated. (Pl. II, figs. 1, 2; Pl. III, figs 1, 2).

It can also be seen from our examinations that the type of soil greatly influences the development of Xyloporosis, and consequently the success of the stock. This is shown by the behaviour of Sweet lime and Rough lemon. The Sweet lime planted on loamy soil was doomed to failure and, if inarching had not been carried out, would have deteriorated completely. This has frequently occurred in similar soils at Mikve Israel and in other groves in the country. Especially instructive is the fact that the inarching of Sweet lime stock with Sweet lime is of no value. Only Egyptian Sour lime and Sour orange strengthen the tree and permit a successful recovery of productivity. On the other hand Sweet lime on light soil succeeded fairly well. The local Rough lemon stocks, planted on light soil, also gave good yields, whereas Rough lemon stock from Florida and California did not succeed in loamy soil. In addition, Rough lemon stock was not a successful inarch for Sweet lime on loamy soil. The above facts show that in the development of Xyloporosis there is one very important retarding factor, namely the quality of the soil in which the stock is planted This constitutes a further indication of the importance of ecology

in the development of this disease. This aspect of the importance of the environmental conditions, especially of the quality of the soil, was emphasized by us in 1934 (5). It is not as yet clear whether it is the hydrothermic or the edaphic factor which is of prime importance. It is also to be noted that BATCHELOR(1) found great differences in the development of lemon decline when grafted to Rough lemon in light soil and in silty loam soil, respectively. From all these facts the general conclusion may be drawn that experiments on the susceptibility of citrus rootstocks to Xyloporosis and other virus diseases should be carried out on both light and heavy soils. Otherwise the experimental results will not be of general value. It is possible that the contradictory results of certain investigators with regard to Tristeza may be ascribed to the differences in the soils used in the experiments.

SUMMARY

1. Observations and examinations were made on Shamouti orange budded to 32 types of rootstock in Mikve Israel. Two types of rootstocks were planted on light soil and all the rest on loamy soil. The purpose of the plantings was to ascertain the compatibility of the stocks with Shamouti.

2. It was found that the decisive factor with regard to the success or failure of the stocks is Xyloporosis. Stocks highly susceptible to this disease are not suited to Shamouti and only those which resist this disease can be considered for use as rootstocks.

3. The rootstocks which in this experiment were found to be resistant to Xyloporosis, when grown in loamy soil, are the Sour oranges of Israel and Baghdad, and the Valencia orange. Less outstanding in their resistance were Sour oranges from Italy, Bitter-Sweet and Willow-Leaf varieties from California, pummelo "Nanas", Egyptian Sour lime, McCarty grapefruit, and various Sweet oranges both local and foreign. Disappointing as stocks were Sour orange from Brazil, Florida and California. Complete failures as stocks were Sweet lime, Rough lemon, Sour lemon, Duncan grapefruit and Trifoliate orange. In light soil, Sweet lime and, to a lesser degree, Rough lemon were satisfactory.

4. As those trees which suffered from Xyloporosis almost invariably showed signs of Little Leaf in the foliage and fruit, there sems to be an identity between these two diseases.

5. Symptoms of Xyloporosis were to be seen not only in the rootstocks but often in the scion as well, and sometimes only in the scion.

6. In addition to the typical xyloporotic pitting, shallow grooves and striations appeared in most instances. Sometimes, tiny needle-like protuberances, which fitted into tiny pits in the inner bark, were also found. This phenomenon was termed "Inverse Xyloporosis".

LITERATURE CITED:

1. Batchelor, L. D., & Rounds, M. B. (1944). Effect of rootstock on lemon decline and yield in two experimental orchards.
— Reprinted from *Citrus Leaves, July,* 1944 : 1—11.
2. Grant, T. J., Costa, A. S., & Moreira, S. (1951). Variations in stem-pitting on Tristeza — inoculated plants of different citrus groups.
— *Citrus Industry,* 32 : 5—7, 15, 18.
3. Reichert, I. (1953). Xyloporosis in Citrus.
— *Proc. of the 13th Internat. Horticult. Congress, London. (In print).*
4. Reichert, I., & Perlberger, J. (1931). Little Leaf disease of citrus trees and its cause.
— *Hadar,* 4 : 183—194, 2 *figs.*
5. Reichert, I., & Perlberger, J. (1934). Xyloporosis — the new citrus disease.
— *Hadar,* 7 : 163—167, 172, 183—202, 15 *figs.*
6. Yedidiah, S. (1937). Citrus growing.
— *2nd edit.* 478 *pp. Tel-Aviv. (In Hebrew).*
7. Yedidiah, S. (1934). Citrus rootstock problems in Palestine.
— *Hadar,* 6 : 233—235, 258—262.
8. Yoffe, I. (1944). Rootstock problems of the Shamouti orange.
— *Hassadeh,* 25 (2) : 38—40, 25 (3—4) : 81—86. (*In Hebrew*).

EXPLANATION OF PLATES I—III

PLATE I.

Fig. 1. Shamouti on local Sour orange. Foliage profuse and healthy.

Fig. 2. Shamouti on Sour orange from Brazil. Decline of the foliage and die-back of the top.

Fig. 3. Shamouti on Sour orange from Florida. Decline of the foliage and die-back of the top.

Fig. 4. Shamouti on Sour orange from California (Standard). Strong decline of the foliage and die-back of the top.

Fig. 5. Shamouti on local Sweet lime. *On the right*: inarched with local Sweet lime, completely declined. *On the left*: inarched with local Sour orange, well developed and healthy.

PLATE II.

Fig. 1. Shamouti on local Sweet lime affected by Xyloporosis. After removal of the bark, the wood of the stock shows pitting and that of the scion shows shallow grooves.

Fig. 2. Shamouti on local Sour orange affected by Xyloporosis. After removal of the bark, wood of the stock and scion shows shallow grooves.

Fig. 3. Shamouti on Weldon Sweet orange affected by Xyloporosis. *On the left*: after removal of the bark, wood shows grooves and slight pitting on stock and scion.
On the right: the striped bark shows on the inner side projections corresponding to the pits and grooves of the wood.

Fig. 4. Shamouti on Duncan grapefruit affected by Xyloporosis.
On the right: after removal of the bark, the wood shows pitting on stock and scion, near the bud union.
On the left: the inner side of the removed bark shows the corresponding projections.

PLATE III.

Fig. 1. Shamouti on local Sweet lime affected by Xyloporosis. After removal of the bark, the wood shows pin-points or "Inverse Xyloporosis" on the scion. The stock, not illustrated here, showed strong pitting.

Fig. 2. The striped bark of the specimen in fig. 1. showing very tiny pits corresponding to the pin-points.

Fig. 3. Shamouti on Rough lemon from Florida affected by Xyloporosis. After removal of a strip of the bark, the wood shows strong pitting on the stock and pin points or "Inverse Xyloporosis" on the scion.

Fig. 4. Lop-sided fruit, characteristic of ""Little Leaf", of Shamouti tree budded on local Sweet lime affected by Xyloporosis.

Fig. 1

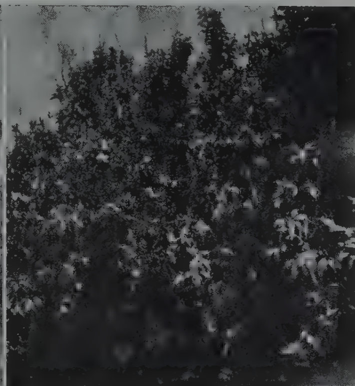


Fig. 2

Fig. 3

Fig. 4

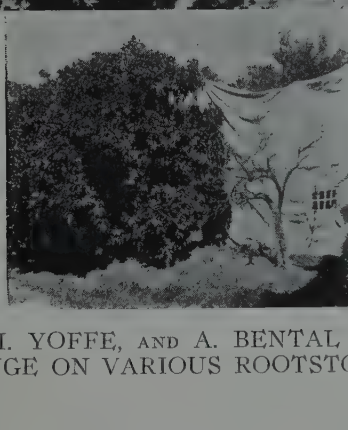


Fig. 5

I. REICHERT, I. YOFFE, AND A. BENTAL — SHAMOUTI ORANGE ON VARIOUS ROOTSTOCKS.

Fig. 1

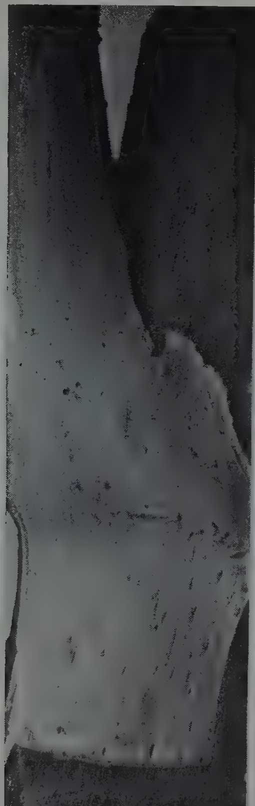


Fig. 2

Fig. 3

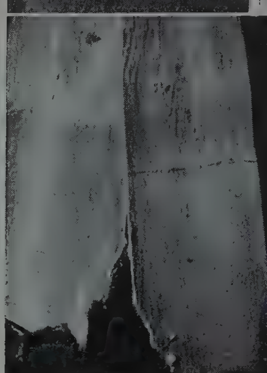


Fig. 4

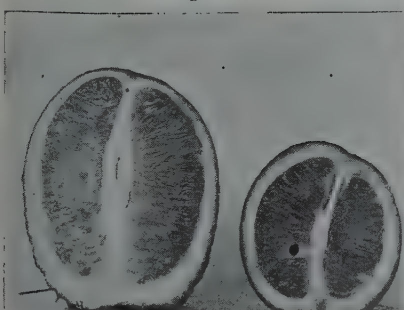
I. REICHERT, I. YOFFE, AND A. BENTAL — SHAMOUTI ORANGE ON VARIOUS ROOTSTOCKS.

Fig. 1

Fig. 2

Fig. 3

Fig. 4



I. REICHERT, I. YOFFE, AND A. BENTAL — SHAMOUTI ORANGE ON VARIOUS ROOTSTOCKS.

DIPHENYL-RESISTANT STRAINS OF DIPLODIA *)

By F. LITTAUER and Y. GUTTER
Division of Plant Pathology, Agricultural Research Station, Rehovot

INTRODUCTION

Diphenyl ($C_6H_5.C_6H_5$) is known to possess fungistatic properties. Its vapour prevents the growth of various fungi, among them some causing citrus fruit rots. To these belongs *Diplodia natalensis* P. E., causal agent of stem-end rot of citrus fruits, one of the main troubles of the Israel citrus industry.

A number of workers (1, 2, 4, 5) investigating the fungistatic action of diphenyl on various fungi, measured the rate of development of these fungi on agar plates in an atmosphere of diphenyl; their observations, however, were confined to a period of one week only. The present authors, while investigating the fungistatic action of diphenyl on cultures of *Diplodia,* lengthened the period of observations. Sometimes, after prolonged action of diphenyl (usually not less than 10 days), there appeared a new growth of *Diplodia* which in spite of the constant presence of diphenyl, continued to grow and to form pycnidia and normal, viable spores. A similar phenomenon has been noticed in the case of some other fungi causing citrus fruit rots, e. g. by Farkas & Aman (1) with *Penicillium digitatum,* and by the authors (3) with *P. digitatum, P. italicum* and *Sphaeropsis sp.*

For further study of this phenomenon, a series of experiments has been carried out in 1945/47 and in 1950. The aim of these experiments was to compare cultures which grew in the presence of diphenyl with the original culture as to: 1) their type and rate of growth, and 2) their pathogenicity.

EXPERIMENTS 1945/47

1. *Type and rate of growth.*

In the first experiment in 1945, the rate of growth of the original isolate of *Diplodia,* no. M 2088, was compared with that of a part of the above isolate, which grew in the presence of diphenyl (this part will here be called isolate "D"). The behaviour of these two isolates in the presence of diphenyl vapour was also examined. Each Petri dish contained 20 mg. of diphenyl. It was

*) Contribution from Citrus Wastage Investigations sponsored by the Citrus Boards.

found, that while the original isolate M 2088 did not develop at all in the presence of diphenyl, isolate D grew from the outset, in spite of the presence of diphenyl, and its rate of growth was almost equal to that of this and the original isolate, when grown without diphenyl. Thus, an isolate "DD", grown twice in the presence of diphenyl, was obtained from isolate "D".—

In 1946 experiments were carried out with the above 3 isolates. Their type and rate of growth in the presence of 20 mg. and 200 mg. diphenyl per Petri dish has been compared with that obtaining in the absence of diphenyl. The diphenyl was applied in the form of crystals and was placed into the lids of the inverted dishes. The cultures were sown on 2% potato-dextrose agar. The plates were kept in darkness at a constant temperature of 25°C The experiment was run in duplicates.

Results showed, that there was hardly any difference in the type and rate of growth of the above three cultures, when grown without diphenyl. There were, however, differences between the cultures when grown in the presence of diphenyl: while the growth of the original isolate M 2088 was completely arrested under the influence of diphenyl, isolates "D" and "DD" grew from the beginning and formed pycnidia and viable spores in spite of the constant presence of diphenyl; their rate of growth was only slightly slower than that of cultures grown without diphenyl. The only difference to be found was the phenomenon of zonation in plates of both isolates when grown in the presence of diphenyl. This zonation was due to a greater density of mycelium and larger quantity of pycnidia in belts arranged in concentric rings or in spirals. The growth of these isolates without diphenyl was smoother and more homogenous, without zonation. There was no difference in the rate of growth of isolates "D" and "DD", or in the effect of doses of 20 mg. and 200 mg. diphenyl upon them.

2. *Pathogenicity.*

Pathogenicity tests were made with isolates M 2088 and "DD" on Shamouti orange fruits in 1946 (one test) and 1947 (two tests).

One batch of fruits was wrapped in plain wraps, another in wraps containing 60 mg. diphenyl each. Prior to inoculation the fruits were surface sterilized with ethyl alcohol, debuttoned and their abscission layer covered with a dense spore suspension of the respective isolate. Each item comprised 10 fruits. The inoculated fruits were stored at 23°C. and high relative humidity for a period of one month. The results of these experiments are summed up in table 1.—

TABLE 1

Inoculation experiments with Shamouti oranges.
(Number of fruits decayed by Diplodia)

Year:		1946	1947 a	1947 b	
Isolate	*Wraps*	*decayed*	*decayed*	*decayed*	*blemished*)*
M 2088	plain	6	10	6	1
	diphenyl	0	0	0	0
"DD"	plain	2	4	0	6
	diphenyl	2	4	0	2

*) Fruits with blemishes round the button; on cuttings the albedo was found to be greyish and of a spongy texture, resembling initial decay subsequently arrested.

Observations were also made on the incubation period, and rate of decaying.

From these experiments the following conclusions may be drawn:

a) Isolate "DD" is less pathogenic to Shamouti oranges than the original M 2088:
   i. Inoculations with isolate "DD" of fruits wrapped in plain wraps were less successful than those with M 2088.
   ii. The incubation period in fruits inoculated with M 2088 and wrapped in plain wraps lasted one week, as compared with 10-14 days in the case of "DD".
   iii. Most of the fruits, inoculated with M 2088, decayed completely within 10 days to three weeks and revealed a soft rot, characteristic of Diplodia; however, the decay of fruits inoculated with "DD" developed much slower, and in most cases failed to make much progress during the observation period: the type of decay here was somewhat like a dry, sunken blemish or pliable rot round the button.

b) The diphenyl-resistant isolate "DD", though less pathogenic than the original, was yet capable of inducing rots in Shamouti oranges wrapped in diphenyl wraps: no difference was observed in the percentage and type of rot, and its rate of development in fruits inoculated with "DD", whether they were wrapped in plain or diphenyl wraps. On the other hand no decay developed after inoculation with the original isolate M 2088 in fruits wrapped in diphenyl wraps.

EXPERIMENTS 1950

1. *Type and rate of growth.*

In 1950, the action of diphenyl on another culture of *Diplodia* was investigated. Here, diphenyl, to the amount of 100 mg. per

dish, was not added immediately after sowing, but to a three-days old culture of *Diplodia* isolate M 1982 grown in Petri dishes on 2% potato-dextrose agar. After being allowed to act for different periods of time, the diphenyl was removed and observations were made on the type and rate of the renewed growth of *Diplodia*. During this experiment we observed a phenomenon similar to that found with M 2088 in the previous years: the growth of *Diplodia* generally became arrested in the presence of diphenyl vapours and started anew only after these were removed; however, sometimes, with the diphenyl vapours still present, a new growth of the fungus appeared in different places of the colony. Arising only from a certain spot on the margin of the colony, this new growth had the form of a fan. As in previous experiments, this new isolate retained its capacity of growing in the presence of diphenyl, even after repeated transfers on agar without diphenyl, and may thus be considered a diphenyl-resistant strain of the original isolate of *Diplodia*.

Observations made on the type and rate of growth of the above strain in comparison with those of the original isolate, revealed full agreement with the results obtained in the previous years, except for the above-mentioned zonation, which was not distinct in the strain from isolate M 1982.

2. *Pathogenicity* .

In the 1950 inoculation tests, Shamouti oranges were debuttoned, surface-sterilized with ethyl alcohol, inoculated into the base of fruit through wounds and the place of inoculation sealed with paraffin wax.

A piece of agar with the mycelium of the respective fungus isolate served as inoculum. Each batch comprised 20 fruits. The following 5 cultures were used for inoculation: the original culture M 1982, two isolates of M 1982, which started to grow one and three weeks, respectively, after the diphenyl had been removed, and two strains from the same isolate that grew in the presence of diphenyl. Another 20 non-inoculated fruits served as control. The conditions of temperature and relative humidity were the same as in the previous experiments. All the fruits were wrapped in plain paper only. (The influence of diphenyl-wraps could not be tested, since the place of inoculation had been sealed with paraffin wax).

Inoculations were successful with M 1982 and those two of its isolates, which started to grow one and three weeks after the removal of the diphenyl; all 60 fruits decayed completely within 7-10 days. In all the decayed fruits we observed a soft rot, beige to brown in colour, and the beginnings of fruiting bodies on the peel. There was no change in the colour of the tissue inside the rotten fruits. The type of decay caused by each of the above three cultures did not differ in any respect. The two strains that

grew in the presence of diphenyl were less pathogenic, and the type of decay caused by them was less uniform. The incubation period lasted up to 2 weeks. The time elapsing before the whole fruit was decayed ranged from two to more than four weeks. Thus, at times, one fruit was already entirely rotten, while the next showed only the first symptoms of decay. Nor was the decay itself uniform: the rot was either soft or pliable, and the peel brown or beige or without any change in colour.

It should also be mentioned, that blackening of the core and the albedo near the button was observed in all the fruits inoculated with the one, and in most of the fruits inoculated with the second of the diphenyl-resistant strains. This blackening was not found in fruits inoculated with the three above mentioned cultures susceptible to diphenyl.

All the reisolations made from a number of fruits yielded *Diplodia.* All the control fruits remained sound.

SUMMARY

1. While diphenyl generally exerts a fungistatic action on the growth of *Diplodia natalensis P. E.,* prolonged exposure of *Diplodia* cultures to diphenyl sometimes yielded a new growth of this fungus starting at a certain point near the margin of the colony and spreading fanlike.

2. Isolates of this new growth developed normally and their rate of development almost equalled that of the original culture, susceptible to diphenyl. Repeated subculturing did not impair the ability of these isolates to grow in the presence of diphenyl. They may, therefore, be regarded as diphenyl-resistant strains of *Diplodia.*

3. Increasing the amount of diphenyl per Petri dish from 20 to 200 mg. did not affect the growth rate of these strains.

4. The diphenyl-resistant strains induced rotting in Shamouti oranges, even where the fruits were wrapped in diphenyl impregnated paper. They were, however, much less pathogenic, incubation periods being much longer and the type of decay less uniform, than with original *Diplodia* cultures, susceptible to diphenyl.

LITERATURE CITED

1. Farkas, A., & Aman, J. (1940). The action of diphenyl on *Penicillium* and *Diplodia* moulds. — *Pal. J. Bot., Jer. Ser.,* 2: 38-45.
2. Littauer, F. & Minz, G. (1942, 1943). Citrus Wastage Investigations. Progress Report 1941/42 and 1942/43, Agr. Res. Sta., Rehovot. Mimeographed.
3. Littauer, F., & Gutter, Y.: unpublished data.
4. Ramsey, G. B., Smith, M. A., & Heiberg, B. C. (1944). Fungistatic action of diphenyl on citrus fruit pathogens. — *Bot. Gaz.,* 106(1): 74-83.
5. Tomkins, R. G. (1935). Wraps for the prevention of rotting of fruit. — *Report Food Investigation Board* 1935: 129-131.

FURTHER TESTS ON THE PATHOGENICITY OF DIPLODIA FROM VARIOUS HOSTS TO CITRUS FRUITS *)

By G. MINZ

Division of Plant Pathology, Agricultural Research Station, Rehovot

In a previous paper (1) results were described of five years' tests on the pathogenicity of *Diplodia natalensis* P. E. from various host plants to citrus fruits .

The present paper records studies over the period from 1944/45 to 1952/53.

New host plants were found affected by *Diplodia* and some new sources or other parts of the hosts that have been tested previously were also included. Sources that gave negative results were tested repeatedly and on different citrus fruits.

Special attention was given to the various isolates which differed morphologically, e. g. isolates from citrus blight usually differ from those of citrus twig gumming.

The method of fruit inoculation was essentially the same as described in the previous paper (1), but fruit was incubated at 23°-25°C.

I. CROSS INFECTIONS WITHIN THE GENUS CITRUS

Shamouti oranges were inoculated by isolate No. 2216 from the root of sweet lime (*Citrus aurantifolia v. dulcis*).

Shamouti and Valencia oranges were inoculated by isolates from a sweet lime twig (2021), a lemon (*Citrus limonia*) fruit (1822), and Shamouti (*Citrus sinensis* Shamouti) twigs affected by blight (1982, 2206), and by gumming (2205).

Valencia oranges were inoculated by isolates from Shamouti orange twigs affected by die-back (1864, 1963), blight (2020), and gumming (1981), and from fruit rots of Shamouti (2025, 2026), and Valencia (*Citrus sinensis* Valencia) orange (2132, 2133, 2134, 2138).

Sweet limes were inoculated by isolates from a sweet lime twig (2021) and from Shamouti twig blight (1982).

All inoculations were successful except those made by the isolate from the sweet lime twig (2021). Incubation period and

*) Contribution from Citrus Wastage Investigations sponsored by the Citrus Boards.

specific rot symptoms were similar for all fruits and isolates. Re-isolations were identical with the original inoculum as regards the type of culture (growth habit, fructification, spores).

Although the isolate from sweet lime (2021) did not differ morphologically from some of the isolates tested, it was found in repeated tests incapable of inducing stem-end rot in either Shamouti or Valencia oranges. Sweet lime fruits exhibited symptoms of rot after 44 days (13 days at 25°C and 31 days at room temperature); four fruits out of ten showed external and four internal black discolouration associated with spore formation.

II. INFECTION OF CITRUS FRUITS FROM HOSTS OUTSIDE THE GENUS CITRUS

In tests carried out from 1944/45 to 1952/53, *Diplodia* isolated from the following sources was inoculated into Shamouti and Valencia oranges, with the results apparent from table I. The incubation period and symptoms of rot were similar to those with isolates from citrus fruits. Results were considered negative where the incubation period greatly exceeded the standard of 5-7 days and where the rot induced after such extended incubation was not of the stem-end type characteristic of *Diplodia.*

Negative results were obtained with the isolate from *Acacia farnesiana* twig (2087) on both Shamouti and Valencia oranges, although another isolate from a trunk (676) of this host was previously (1) found positive on Shamouti orange and in this test on Valencia.

Only one isolate of *Diplodia* from date palm (1826) was positive. The remaining isolates induced rot after a prolonged incubation period in Shamouti (18-20 days), and not at all in Valencia.

The isolate from *Prunus avium* (2291) was capable of inducing stem-end rot in Shamouti oranges after 13 days only, but induced rot in Valencia oranges within the normal period of 5-7 days.

The isolate from *Pyrus syriaca* (1799) gave negative results with Valencia as it did previously with Shamouti oranges (1).

Grapefruit and lemon fruit inoculations gave positive results with the isolate from *Ficus nitida* (1702), and lemon fruits also with that from Winter banana apple twig (2048).

CONCLUSIONS

The above investigations have shown that stem-end rot in citrus fruit may be induced by a large number of *Diplodia* isolates from various hosts both within and outside the genus *Citrus.* But there were some exceptions, even within the genus *Citrus* (isolate 2021).

TABLE I.

Positive (+) and negative (—) results after inoculation of Diplodia from various sources into Shamouti and Valencia orange fruits.

Source	Part affected	No. of isolate	Shamouti	Valencia
Acacia farnesiana	trunk	676		+
	twig	2087	—	—
Acer negundo	root	2213	+	+
Casuarina sp.	trunk	2287, 2288	+	+
Cotoneaster sp.	collar root	2215	+	+
Cupressus pyramidalis	collar	1833	+	
Cydonia oblonga, quince	fruit	1771	+	
Diospyros khaki, persimmon	twig	2290	+	+
Erythrina sp.	branch	2302	+	+
Ficus nitida	branch	1702, 2214	+	+
Hordeum sativum, barley	seed	2175	+	+
Mangifera indica, mango	scion *)	2365, 2370	+	
Persea gratissima, avocado	fruit	1695	+	
Phoenix dactylifera, palm	leaf stalk	436		—
	leaf stalk	1764	—	
	leaf stalk	1826	+	+
	male flower	1770	—	
	root*)	2371	—	—
	leaf*)	2372	—	—
	leaf stalk*)	2373	—	—
Prunus amygdalus v. amara, bitter almond	collar	2143	+	+
P. avium, Mazard stock	collar	2291	–	+
P. armeniaca, apricot stock	collar	2144	+	+
P. persica v. nucipersica, nectarine	twig	2289	+	+
Pyrus malus, Winter Banana apple	twig	2048	+	+
P. syriaca, wild pear stock	stem	1799	—	—
Rosa sp., rose	stem	1990	+	
Vitis vinifera, vine stock	stem	2300	+	+

Without discussing the taxonomy of the *Diplodia* isolates used in this investigation (which is to be the subject for a separate study), it was found that the pathogenicity of the isolates was independent of their morphological and cultural characters. Two exceptions, however, may be mentioned: *Diplodia* from date palm (436) and from wild pear (1799), both being morphologically different from the remaining isolates, were also different in their pathogenicity.

LITERATURE CITED:

1. MINZ, G. & BEN-MEIR, YOHEBED (1944). Pathogenecity of *Diplodia* from various hosts to citrus fruits. — *Pal. J. Bot.,* Rehovot Ser., 4: 162-165.

*) Received from abroad through the Division of Plant Protection, Jaffa, whose co-operation is herewith acknowledged.

CONTACT TRANSMISSION OF DIPLODIA ROT IN SHAMOUTI ORANGE FRUITS *)

By MINA NADEL-SCHIFFMAN,
Division of Plant Pathology, Agricultural Research Station, Rehovot

The *Diplodia natalensis* P.E. fungus causing the stem-end rot of citrus fruits penetrates the latter through their stem-end and *Diplodia* rots originating from the peel hardly ever occur in nature (3, 4). Experiments have shown that inoculation through the peel will succeed only after the peel has been injured (1,2,5) or occasionally without injury at very high moistures and with an agar culture inoculum (2). This study was to elucidate whether, and more particularly under what conditions, *Diplodia* stem-end rot may be transmitted by contact from decayed to sound Shamouti orange fruit.

Two years' experiments were carried out at 18° C in two groups under different humidity conditions: Group A comprised in the first year 100, in the second 200 sound fruits normally wrapped and packed in export cases and kept at 80% relative humidity. These were placed in contact with fruit inoculated with *Diplodia* at their stem-end on the day the experiment began. In this case the sound fruit came into contact with decayed fruit only after 6-8 days, the period elapsing between inoculation and appearance of the decay on the peel.

Group B consisted of 50 sound unwrapped fruit kept in a moisture saturated atmosphere in "moisture chambers". Sound fruit was from the outset placed in contact with decayed fruit.

RESULTS

Results indicated that after 14-21 days' contact between decayed and sound fruit more than half the number of the latter began to show blemishes (nouksan) at the point of contact, consisting of depressions without change in colour. Some of these blemishes were small (up to 5 mm in diametre) and some large (5-20 mm). The blemishes were at first firm but softened within a week, and after a further week of contact *Diplodia* soft rot usually developed from the blemish.

Re-isolations were attempted from the blemishes at various times after their appearance, often successively several times from

*) Contribution from Citrus Wastage Investigations sponsored by the Citrus Boards.

the same blemish. No fungus could be isolated from the blemishes within 7 days of their appearance, but later, while still firm, they frequently yielded *Diplodia.* Once they had sof.ened, the blemishes on culturing always produced *Diplodia.*

These observations led us to assume that the blemishes initially represent only peel injury caused by contact with decayed fruit. This injury appears to enable the fungus to penetrate the fruit after some time.

Blemishes were observed to form not only on fruit in contact with decayed fruit, but also on fruit in the bottom layer of the export case. This fruit was under pressure and in prolonged contact with the box wood moistened by the juice of decayed fruit. Here small blemishes developed only on that part of the fruit which touched the moist wood. It is thus evident that blemishes may also develop without direct contact with decayed fruit, solely by the action of the juice of such fruit. This may be assumed to be due to enzyme action. In no case could *Diplodia* be isolated from blemishes due to contact with juice moistened wood alone.

There were no well-marked differences between the results observed in groups A and B at different levels of humidity, except that in the moisture chambers (group B) formation of blemishes and softening of the fruit preceded that of the fruit kept at 80% humidity (group A) by 5-7 days.

CONCLUSION AND SUMMARY

These experiments show that *Diplodia* rot of Shamouti oranges is transmissible by contact from decayed to sound fruit.

The sound fruit after 2-3 weeks of contact shows blemishes of various sizes. No *Diplodia* could be isolated from these blemishes within the first week of their formation. The blemishes are at this stage to be considered only as superficial peel injuries due apparently to enzyme action on contact with the decayed fruit. But *Diplodia* was isolated from the blemishes after more than a week in most cases in which the blemished peel was still firm, and almost invariably after that peel had softened. We may thus assume that this blemish facilitates contact transmission of *Diplodia* from decayed to sound fruit.

Although our experiments have established that fruit may contract *Diplodia* rot by contact, there seems to be little likelihood of such disease transmission under normal export conditions involving a transit period of 3-4 weeks. This follows from the fact that the incubation period of *Diplodia* stem-end rot together with the period required for formation of blemishes and contact transmission of the rot add up to 4-6 weeks. However, in prolonged periods of transit or storage, such as obtain where shipments are delayed or fruit is stored for out-of-season marketing, the danger of *Diplodia* rot spreading by contact cannot be neglected.

LITERATURE CITED

1. Bates, G. R. (1937). VII. Diseases of Citrus fruits in Southern Rhodesia Mazoe Citrus Experimental Sta. Publication No. 60.
2. Littauer, F., Nadel-Schiffmann, M., & Minz, G. (1947). The mode of infection of Shamouti Oranges by Diplodia. *Palestine Journ. Bot. Rehovot Ser.* 6(1-2) : 158-164.
3. Minz, G. (1946). Diplodia natalensis, its occurrence on flowers, button, and stem-end of Shamouti orange, and its relation to stem-end rot and fruit drop. — *Palestine Journ. Bot., Rehovot Ser.,* 5(2) : 152-168. Bull. 42, Agric. Res. Sta.. Rehovot.
4. Nadel, M. (1944). Anatomical Study of the button of Shamouti oranges in relation to stem-end rot. — *Palstine Journ. Bot., Rehovot Ser.,* 4(2) :166-170.
5. Reichert, I., & Hellinger, E. (1931). Further experiments on the Control of Diplodia Stem-end Rot of Citrus Fruits by Debuttoning. *Hadar,* Vol. IV No. 10.

THE DIE-BACK OF ALEPPO PINES AND ITS RELATION TO MYCORRHIZA DEVELOPMENT

I. WAHL[1]) and I. REICHERT[2])

The Aleppo pine, *Pinus halepensis* Mill., ist the main constituent in one of the most important climax associations of the Mediterranean vegetation of Israel. The remnants of the preserved vegetation have prompted a hypothesis that the *Pinus halepensis* forest has covered vast areas in the Mediterranean region of the ancient Land of Israel: from the Hebron district to the Syrian border and to Northern Transjordania(3). The forest predominates on grey, highly calcareous, soils that originated from soft chalk rocks. The roots of the trees are shallow and do not penetrate deep into the substrate(10).

In the afforestation program pursued in Israel, the Aleppo pine plantings are the most prevalent and appear to be very successful. In the last twenty years, however, a serious disease has affected these forests inflicting considerable damage to the trees.

THE DISEASE

Description

The sick trees are characterised by a yellowing of the needles, and a twisting and curling of the shoots (text-fig. 1). The discoloration sets in at the base of the needles which droop down and shed prematurely, leaving the shoots bare. The discoloration becomes more and more pronounced in the xylem of the branches and trunk, and ultimately reaches the roots. Finally, the pine dries out and degenerates completely.

Distribution and economic importance

The first appearance of the disease was recorded in the Mount Carmel plantations in 1933. Near Ahuza, in a forest patch consisting of approximately 6000 trees, 550 died very rapidly whilst 700 partly affected trees survived for a short period, but deteriorated soon after. In later years the malady spread quickly and caused severe losses to the Aleppo pine plantations, primarily in some settlements of the Esdraelon Valley, and adjoining hill country such as Ein-Hashofet, Ginegar, Kfar Hachoresh, Mishmar Haemek, and

[1]) Faculty of Agriculture, Hebrew University, Jerusalem.

[2]) Division of Plant Pathology, Agricultural Research Station, Rehovot, and Faculty of Agriculture, Hebrew University, Jerusalem.

Shaar-Haamakim. In certain forest plots over fifty per cent of the pines died. It is interesting to note that only Aleppo pines suffered from the disease, while *Pinus pinea* and *Pinus brutia* remained healthy.

Influence of ecological factors

The damage was exceptionally heavy on eastern sites that are subject to drought and spells of hot desert wind. The severity of the malady also seems related to certain edaphic conditions. On steep slopes, where litter and humus were washed off by driving rains the trees declined rapidly. On the adjacent, flatter plantations the growth was satisfactory. Likewise, pine trees planted on patches previously destroyed by fire were adversely affected in their development.

It became very noticeable that in the normal plantations, mush-

Text-fig. 1. Shoots of diseased Aleppo pines showing symptoms of curling and twisting.

room crops particularly of *Boletus granulatus* were abundant whilst in the diseased plots the same mushroom species gave poor yields.

Possible causes

Careful examination of the defective specimens from different localities did not reveal the presence of any pathogenic organism that might have been responsible for the decline of the trees. The pine scale *Matsucoccus sp.* was frequently found on diseased Aleppo pines and caused serious damage to the trees (2a), but in many plantings affected trees in the initial stage of disease were free of *Matsucoccus*. It is thus evident that the disease was not caused by entomological factors alone.

In view of the fact that certain pine growth disturbances, resembling the Aleppo pine disease and caused by unfavourable ecological factors, are invariably reflected by aberrant mycorrhizal structure (1,2,8,9), the authors have undertaken a study of mycorrhizae in thriving and in feeble Aleppo pines.

MATERIALS AND METHODS

Sampling

For comparative studies, samples have been collected in Aleppo pine forests at the following localities: Ben-Shemen, Ginegar, Kfar Hachoresh, Mishmar Haemek, and Shaar Haamakim. Special attention was given to the comparison of healthy and diseased trees of the same age, and to the examination of the rootlets growing at equal depth and distance from the tree trunk (approximately 1.5—2.0 metres). Samples were collected during the winter season, under optimum conditions for mycorrhizal development, and preserved in a formalin—glacial acetic acid—alcohol fixative (9).

Microscopic study

Numerous data have been accumulated to prove that the internal structure of mycorrhizae belonging to trees of poor stands deviate from the ordinary type and probably reflect the disturbance of the biological equilibrium between the plant and its environment (1, 2, 5, 6, 8, 9).

The prerequisite for correct interpretation of the deviations involved, and for securing a reliable index for estimation of ecological conditions connected with thrifty or meager growth, is an extensive study of the internal mycorrhiza structure in normal tree specimens growing in various soils where tree stands are satisfactory and the plant-environment relation well balanced. The recognition and establishment of the standard for comparison "will render it possible to detect the abnormal, moribund deviations from the structure type regarded as normal."(8).

Freehand transverse sections, and microtomic longitudinal

sections were mounted in a 0.5% solution of cotton blue in lacto-phenol, gently heated and left in stain for a few hours. In certain slides, differentiation was attaind by rinsing in lacto-phenol for several minutes. Another method employed was to stain the sections for 30 minutes in a saturated solution of orsallin BB in 3% aqueous acetic acid, and then counterstaining with a 1% sol. of crystal violet in clove oil — in accordance with the procedure recommended by JOHANSEN (4). This latter method is inferior to the cotton blue method. On the other hand, however, the cotton blue staining does not hold well and fades with time.

RESULTS

External structure of Aleppo pine mycorrhiza

In the normal trees mycorrhizae are readily discernible by their profuse, dichotomous branching, and yellow colour. All our samples should be classified as coralloid mycorrhiza [Gabelmykorrhizen (5, 6)], although in some cases, when clusters of crowded forklike rootlets are wefted together by a thick mantle, the mycorrhiza becomes tuberlike. The mycorrhizae of abnormal pines are slender, featured by smaller diameter of the rootlets, darker colour, and scanty branching (text-fig. 2). Similar differences between mycorrhizae of healthy and diseased pines are reported from other countries (8, 9).

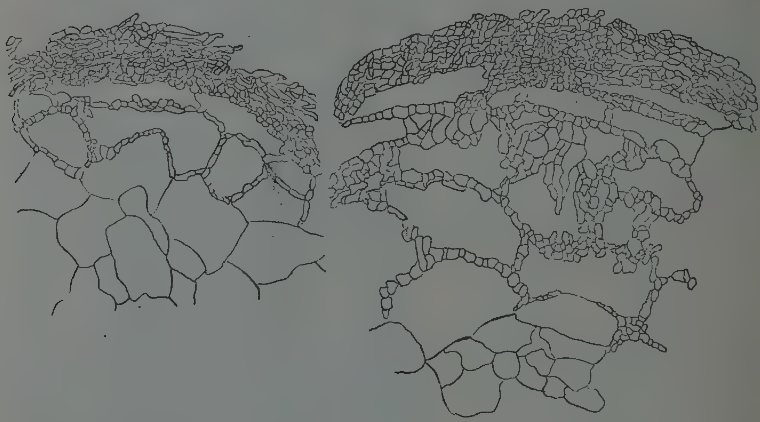
Text-fig. 2. Rootlets of a diseased Aleppo pine (left) as compared with rootlets of a healthy tree (right). The latter are thicker and produce better developed lateral branches of coralloid type (x 3).

The comparative studies dealt with the following parts of the mycorrhiza :

A. THE MANTLE

It was ascertained that there is no difference in the thickness of the hyphal sheath (mantle) enveloping the diseased and healthy Aleppo pine rootlets. In both cases the mantle consisted of 5—10 hyphal layers (text-figs. 3, 4). The mantle of the abnormal tree mycorrhizae was frequently embedded in a brown exudate which gave negative reactions with reagents used for identification of tannins, fats, and resins(7). In healthy mycorrhizae no exudate was apparent.

It is interesting to note that, in contradiction to our findings, YOUNG(9) has reported that the mantle of mycorrhizae deriving from poor stands is very thin and sometimes lacking. BJOERKMAN arrived at a similar conclusion emphasizing that the fungal mantle of weak plants is meagerly developed.(1,2.).



Text-fig. 3 *Text-fig.* 4

Text-fig. 3. Transverse sections through a mycorrhizal rootlet of a normal Aleppo pine. The mycorrhiza is ectotrophic and equipped with a thin Hartig network, restricted to the outer cortex layers. A mycelial sheath (mantle), envelops the rootlet. (Camera lucida drawing, x300).

Text-fig. 4. Transverse section through a mycorrhiza of a diseased Aleppo pine. The Hartig net is overdeveloped, thick, produces abundant intracellular invasions and reaches as far as the endodermis. The width of the mantle is equal to the mantle in a normal mycorrhiza (Camera lucida drawing, x400).

B. THE HARTIG NET

The authors have established that in the mycorrhizae of normal Aleppo pines, the Hartig net is relatively thin. It consists of 1—2 hyphal strands and is restricted to 1—2 outer cortex cell layers. The hyphal cells are 3.0—3.25μ wide (average of 100 measurements). The mycorrhiza is predominantly ectotrophic and only very rarely do the cortex cells reveal the presence of inconspicuous mycelial fragments (text-fig. 3). The outstanding features of mycorrhizae taken from normal Aleppo pines are essentially in line with the descriptions reported for mycorrhizae of other pine species thriving under favourable conditions (1, 2, 5, 6, 9).

Sections through mycorrhizae of defective Aleppo pines showed that the Hartig net is thick and overdeveloped. The net is composed of 2—4 hyphal strands containing broad cells, 4.5 μ wide (average of 100 measurements). These abnormalities of the Hartig net became even more obvious in severely affected pines. In the latter instance, the external cortex layers of the rootlets were disintegrated and absorbed by the exceptionally thick mycelial network.

Further examination of our slides proved that the cortical cells of the outer layers were profusely invaded by haustoria branching out from the Hartig net, and the net itself reached as far as the endodermis (text-fig. 4).

The above described alterations in the structure of mycorrhizae observed in Aleppo pine trees of poor growth closely resemble the characteristics of mycorrhizae in abnormal trees of other pine species. Several authors have discovered in the cortical cells of abnormal pine rootlets, abundant haustorial invasions deriving from the Hartig network (1, 2, 5, 8, 9), which is vigorously developed, being two or more strands thick. Regarding the depth of penetration of the Hartig net it should be mentioned that Bjoerkman has demonstrated that in mycorrhizae of weak pines the hyphae are located chiefly in the deeper layers of the cortex and reach the endodermis (1, 2).

DISCUSSION

Summarizing the results of extensive forest surveys and examinations of morphological and anatomical characters of Aleppo pine mycorrhizae carried out for several years, the writers are inclined to postulate that the Aleppo pine die-back in Israel is related to defective mycorrhiza formation, and that the latter is associated with abnormal ecological (primarily edaphic) conditions.

One of the main reasons for this deterioration must be sought in the abnormal ecological conditions since it was established that wherever the disease prevailed, the ecological factors deviated from the normal.

The writers' observations attesting to the conclusion that the depletion of litter and humus was causally related to pine growth impoverishment, are in accord with YOUNG's findings(9). Investigations reported by YOUNG ascribe to the litter coverage of the forest great importance for the successful growth of the trees. YOUNG's assertion that fires affected the soil layer adversely and made it unsuitable for vigorous pine development, was fully confirmed by our experience in Israel.

The authors are of the opinion that the beneficial influence of the litter and the humus can be explained by their protective action in preventing soil drought and by increasing the soil moisture capacity. In addition, it is conceivable that by removing the litter and humus, the soil is deprived of some nutritive materials and of growth promoting substances that stimulate the development of pines by invigoration of the mycorrhizae or in some other way (2). The hypothesis put forward by RAYNER and NEILSON-JONES(8) that humus influences favourably the development of the pines due to the removal from the soil of certain materials toxic to mycorrhizal fungi, seems also to be feasible.

Recent investigations have indicated that soil factors in a given forest habitat are correlated with certain types of mycorrhizae and even determine their structure. Consequently, it is inferred that "the condition of the root system in respect to the mycorrhizal and pseudo-mycorrhizal development may be regarded as an index of the suitability or otherwise of the soil environment"(8).

The results of the examinations presented here seem to prove that alterations in the morphology and anatomy of the mycorrhizae reflect the nature of the ecological conditions (chiefly edaphic) and their influence on the Aleppo pines. Furthermore, the authors agree with other investigators (1, 2, 9) in considering the overdevelopment of the Hartig network and the abundance of intracellular invasions in the root cortex of the diseased pines as manifestations of the increased parasitic tendency of the fungus under unfavourable edaphic conditions.

The present experimental data do not suffice to express a definite view on the controversial problem whether the fungus by its more or less parasitic tendency brings about the feeble growth of the higher plant and the malformations involved, or whether the tree, weakened by the deleterious environmental factors, fails to resist the aggressive expansion of the hyphae and to prevent them from entering the root cells (2). It seems doubtful whether such a sharp distinction is possible at all.

Be the final answer to this physiological question as it may, it seems justifiable to conclude that detailed knowledge of the anatomical structures of mycorrhizae from good and poor stands, respectively, and correct interpretation of the information thus secured will be of paramount importance for a better understanding of ecological factors which is indispensable for successful afforestation.

SUMMARY

1. The importance of the Aleppo pine (*Pinus halepensis* Mill.) in the natural vegetation of the Mediterranean region of Israel, and in the country's afforestation project is outlined.
2. Serious tree growth abnormalities are described as manifested by stunting of the pines, curling and twisting of the shoots, chlorosis, yellowing and shedding of the needles, and premature death.
3. Ecological conditions (chiefly edaphic) constantly associated with the appearance of the disease are discussed.
4. Studies of the external and internal structure of mycorrhizae belonging to healthy and sick pines proved that in the latter the mycorrhizae are darker, thinner, and sparsely branched. It was also concluded that the Hartig net in the rootlets of the feeble trees is thick, intracellular to a considerable extent, and reaches the endodermis. The mycorrhizae of normal trees are primarily ectotrophic with a thin Hartig network, restricted to the outer cortex layers. No difference in the thickness of the mycelial mantle in mycorrhizae of normal and abnormal Aleppo pines could be noticed.
5. The conclusion was drawn that this disease of Aleppo pines is associated with unfavourable ecological conditions reflected in the development and structure of the mycorrhizae. Consequently, a detailed knowledge of the mycorrhizal types and structures from fertile and poor stands may serve as a reliable indicator for identification and proper evaluation of ecological factors necessary for successful afforestation.

LITERATURE CITED

1. Bjoerkman, E. (1942). Über die Bedingungen der Mykorrhizabildung bei Kiefer und Fichte. *Sym. Bot. Ups.* 6(2) : 1—191.
2. Bjoerkman, E. (1949). The ecological significance of the ectotrophic mycorrhizal association in the forest trees. *Svensk. Bot. Tidskr.* 43, (2—3) : 223—262.

2a. Bodenheimer, S. (1950). Protection of Forests in the Near East. *Hayaar,* 2, pp. 32—35. (Hebrew).

3. Eig, A. (1946). Synopsis of the phytosociological units of Palestine. *Palestine Jour. Bot., Jerusalem Ser.,* 3 : 184—246.
4. Johansen, D. A. (1940). Plant microtechnique. (First Edition) McGraw-Hill Book Co., Inc. New York and London, pp. 523.
5. Melin, E. (1923). Experimentelle Untersuchungen über die Konstitution und Ökologie der Mykorrhizen von Pinus silvestris L. und Picea Abies (L.) Karst.—Mykol. Unters. u. Ber. von R. Falck, 2 : 73—331.
6. Melin, E. (1925). Untersuchungen über die Bedeutung der Baummykorrhiza. Eine ökologisch-physiologische Studie. Gustav Fischer, Jena, pp. 152.

7. RAWLINS, T. E. (1935). Phytopathological and botanical research methods. John Wiley & Sons, Inc. New-York; Chapman & Hall, Ltd. London. pp. IX + 156.

8. RAYNER, M. C., & NEILSON-JONES, W. (1944). Problems in tree nutrition. Faber and Faber, London, pp. 184.

9. YOUNG, H. E. (1940). Fused needle disease and its relation to the nutrition of Pinus. *Queensland Dept. Agric. and Stock. Div. Plant. Ind.* (Research). *Bull.* 17. (New Series) 1—108.

10. ZOHARY, M. (1944). Introduction to the Geobotany of Palestine. Publ. "Sifriat Poalim" Workers' Book Guild (Hashomer Hatzair), Palestine. (Hebrew).

FIELD OBSERVATIONS ON THE HUMIDITY RELATIONSHIPS OF TWO POWDERY MILDEWS IN ISRAEL

by J. PALTI,
Formerly of the Division of Plant Pathology, Agricultural Research Station, Rehovot.

Powdery mildews form a dominant group in the fungus flora of Israel, but this group is far from homogeneous in the conditions favouring the occurence of its members. It is our intention to present some field data bearing on the humidity relationships of two powdery mildews of common occurrence here, viz. those affecting potatoes and cucumbers. Both are of the *Oidium* type. No perithecia have so far been found in Israel on potatoes. On the other hand, RAYSS(5) has described perithecia found in the Jordan Valley on cucumbers and vegetable marrows affected by powdery mildew, and has identified this mildew as *Sphaerotheca fuliginea* (Schlechtendal) Salmon. However, pending further investigation of this disease in other parts of the country, we prefer to refer to the fungus found on cucumbers, as to that found on potatoes, as *Oidium sp.*

MOISTURE CONDITIONS IN VARIOUS DISTRICTS OF ISRAEL DURING THE SUMMER MONTHS

Though throughout Israel the summer months are entirely rainless, differential atmospheric humidity and dew formation nevertheless bring about wide divergences in the moisture conditions in various parts of the country. Table I presents mean relative humidity data collected by ASHBEL(2) for some selected localities representative of their respective districts.

These data support the following conclusions:

(1) Mean relative humidity, both during the 24-hour and the 12-hour day-time period is in general highest in December-February, then descends to its lowest level in May, reascends to a second peak in August and shows another dip in October.

(2) The annual mean of relative humidity for the whole 24-hour period is fairly uniform (between 72 and 75,4%) in all the districts with the exception of the Southern Hule basin (Ayelet-Hashachar), where it reached only 61%.

(3) Mean relative humidity for the 24-hour period is not quite so uniform, even apart from the Southern Hule, where individual months are considered: Thus in January-February

TABLE I.

Records of the percentage of mean daily relative humidity for various districts of Israel

District	Locality & years of recording	Daily period recorded	Annual mean	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Upper Galilee (Northern Hule)	Dan 1939—43	24 hours	72.0	79	75	79	72	59	68	76	76	75	65	66	75
		8 a.m.- 19 p.m.	62.0	73	70	70	60	45	56	63	63	63	54	58	69
Upper Galilee (Southern Hule)	Ayelet Hashachar 1937—43	24 hours	61.0	70	68	65	57	48	52	60	61	65	58	61	68
		8 a.m.- 19 p.m.	51.7	66	62	58	48	37	39	44	49	52	48	54	63
Upper Jordan and Beisan Valleys	Tirat Tsvi 1938—43	24 hours	74.3	84	85	81	71	60	67	71	74	71	70	74	83
		8 a.m.- 19 p.m.	60.5	76	76	69	53	41	49	55	59	57	57	62	72
Harod Valley	Ain Harod 1936—38	24 hours	73.8	82	80	73	69	72	70	76	77	76	68	74	69
		8 a.m.- 19 p.m.	63.2	77	73	63	57	57	58	60	64	64	57	65	64
Western Valley of Esdraelon	Mishmar Haemek 1938—43	24 hours	73.1	78	77	77	70	64	69	73	76	75	72	72	74
		8 a.m.- 19 p.m.	61.8	71	72	69	59	48	53	57	60	57	60	61	66
Northern & Central coastal Plains (Acre—Tel-Aviv)	Petah Tiqva 1938—43	24 hours	75.4	78	78	75	73	69	78	80	81	80	77	76	80
		8 a.m.- 19 p.m.	68.4	73	71	68	63	58	66	69	70	70	68	69	76
Southern Coastal Plain	Rehovot 1937—43	24 hours	72.5	74	74	75	67	65	73	75	76	73	70	71	77
		8 a.m.- 19 p.m.	60.8	65	64	64	54	51	58	61	62	60	59	62	70

this mean ranges from 74% in the southern coastal plain (Rehovot) to 84-85% in the Beisan Valley; whereas in May the central coastal plain (Petah-Tiqva) and the Harod valley registered means of 69-72% as against 59-60% in the Beisan Valley (Tirat Tsvi) and the Northern Hule (Dan).

It is thus evident that the uniform annual means are in some cases derived from widely divergent monthly values (e. g. 69 to 81% in Petah Tikva, mean 75,4%).

(4) In the relative humidity values for the 12-hour period from 8 a. m. to 19 p. m. the annual mean indicates three levels: The Southern Hule is again by far the lowest (51.7%), the central coastal plain is highest (68.4%) while all the other districts are intermediate (60-63%).

But in the months of April-May the gap between the Southern Hule and at least one member of the intermediate group, the Beisan Valley, is narrowed down to only 4-5%, with the Northern Hule also reaching a very low point in May.

To summarize: The Southern Hule basin is definitely the driest of all the districts considered. The remaining districts are distinguished mainly by the level to which mean humidity falls during day-time in the driest season (May); according to this criterion the Beisan Valley and Northern Hule are also dry, followed by the Western Valley of Esdraelon and then the southern coastal plain. The Harod valley has a relatively high mean value for this season, and the northern plain is the most humid.

GENERAL DISTRIBUTION OF POTATO AND CUCUMBER MILDEWS IN ISRAEL

Table II indicates the distribution of the powdery mildews of potato and cucumber in the seven districts for which humidity data are presented in table I, for the three-year period 1942-1944.

Table II shows wide divergence, if not contrasts, in the distribution of the two powdery mildews. On potatoes the disease is entirely absent from the coastal plain (apart from a trace once found in Givat Brenner); it is occasionally found, though only slightly developed, in the Western Valley of Esdraelon. But more frequent and severe occurrence of the potato mildew is restricted to the northern and southern Hule districts and the Upper Jordan, Beisan and Harod Valleys.

As for cucumbers, their growing season is restricted in the coastal plain and Hule districts to spring and summer, and in the valleys to spring and autumn. Apart from early spring, powdery mildew has been found at all seasons with development ranging from slight to very severe. The records of severe occurrence of cucumber mildew include both years and localities in which potato

TABLE II.

Distribution of powdery mildews of potato and cucumber over seven districts of Israel in 1942-1944

* = *copious development;* † = *slight to moderate development;* — = *absent*

		Febr.-March	Apr.-May	June-July	Aug.-Sept.	Oct.-Nov.	Dec.-Jan.
I. *Powdery mildew of potatoes*							
1. Northern Hule	1942		†	*	*	—	
	1943		—	†		—	†
	1944		—				†
2. Southern Hule	1942		†			†	— —
	1943	—		†			*
	1944		—				
3. Upper Jordan & Beisan Valleys	1942	**	†		—	— —	—
	1943	— —					— —
	1944	—	†—			††	
4. Harod Valley	1942	†	†		—		— —
	1943	— —				—	*
	1944					—†	
5. Western Valley of Esdraelon	1942		†	†		—	— —
	1943			— —		—	
	1944					— —	
6. Northern & central coastal plain (Acre—Tel-Aviv)	1942		— —	—	— —	— —	— —
	1943	— —	— —	— —		— —	—
	1944		— —			—	
7. Southern coastal plain	1942		—	—		—	— —
	1943	—	— —	— —	—	—	†
	1944		—			—	
II. *Powdery mildew of cucumbers*							
1. Northern Hule	1942				†	†	
	1943				†	*	
	1944						
2. Southern Hule	1942						
	1943						
	1944						
3. Upper Jordan & Beisan Valleys	1942					†*	
	1943					*	
	1944						
4. Harod Valley	1942					†*	
	1943					†*	*
	1944						
5. Western Valley of Esdraelon	1942						
	1943						
	1944						
6. Northern & central coastal plain (Acre—Tel-Aviv)	1942		—	†*		†	
	1943		— —	†*			
	1944		†				
7. Southern coastal plain	1942			*	†††		
	1943			*	*		
	1944		†				

mildew was entirely absent (coastal plain in all years, Upper Jordan Valley in autumn 1942) and those in which the mildew on potatoes was rampant (Northern Hule, summer 1942).

If we attempt to fit the above general distribution of the powdery mildews to the humidity data presented in table I, we are led to the conclusion that the level of relative humidity is not a decisive factor in determining the distribution of the cucumber mildew. On the other hand, the potato mildew is conspicuously absent from the more humid coastal plain and most frequent and severe in driest districts, the northern and southern Hule and the Upper Jordan and Beisan Valley. Only the frequent occurrence of this disease in the Harod Valley, which according to the meteorological data quoted is somewhat more humid, does not agree with the otherwise clear trend of the potato mildew to be limited to dry conditions.

However, no more than a pointer, and certainly no complete agreement, can be expected on this point where macroclimatical averages for several years are used and the district is not at all uniform microclimatically. We shall now proceed to examine, whether humidity data for the actual months for which records of potato and cucumber mildews are available, can define more precisely the humidity relations of these diseases.

SPECIFIC RECORDS OF POWDERY MILDEWS ON POTATOES AND CUCUMBERS AND THE RELEVANT HUMIDITY DATA

i. *The powdery mildew on potatoes*

Table III presents a number of records of the presence or absence of the potato mildew in 1942-1944 in various parts of the country, together with the mean humidity data recorded at the nearest meteorological station for 1-3 months preceding the record as published by ASHBEL (1).

The data presented in table III confirm, in the first place, that no clear relationship exists between the occurrence of the powdery mildew on potatoes and the monthly mean of relative humidity for the 24 hour period of day and night time. Where this value approximated 65-70 percent. the powdery mildew sometimes appeared (e.g. Ayelet Hashahar, Tirat Tsvi and Ramat David in spring 1942) but frequently failed to appear (e. g. Dafna, Ayelet-Hashahar in autumn 1942, Herzlia and Givat Brenner in spring 1943).

On the other hand, there is considerable evidence that the level of humidity during day-time (8 a.m.—19 p.m.) affects the appearance of this mildew on potatoes. Outbreaks were in all cases preceded by at least one month in which the mean of day-time humidity fell below 50 percent., whereas there was not a single case

TABLE III.

Records of potato mildew in relation to humidity data

District	Details of record				Relative humidity data			
	Locality	Date of planting	Date of record	Degree of infection	Locality of met. station	Month and year	Monthly mean rel. humidity 24 hrs.	8 a.m 11 p
1. Northern Hule	Dafna	III.42	25.VI.42	severe	Dan	April '42	68	5
						May '42	62	4
						June '42	57	4
	Dafna	VIII.42	16.X.42	none	Dan	Sept. '42	73	5
						Oct. '42	67	5
	Amir	VIII.44		severe	Dan	Sept. '44	59	4
			14.XII.44			Oct. '44	70	5
		25.IX.44		none		Nov. '44	84	7
2. Southern Hule	Ayelet Hashahar	II.42	25.V.42	severe	Ayelet Hashahar	March '42	71	6
						April '42	67	47
						May '42	52	4
	Ayelet Hashahar	VIII.42	15.X.42	none	Ayelet Hashahar	Sept. '42	68	5
		IX.42	1.XII.42	none		Oct. '42	70	6
		X.42	11.II.42	none		Nov. '42	84	8
		XI.42				Dec. '42	73	6
						Jan. '43	83	7
	Ayelet Hashahar	III.43	23.VI.43	moderate	Ayelet Hashahar	April '43	68	57
						May '43	62	47
						June '43	56	42
3. Upper Jordan & Beisan Valleys	Kinneret	I.43	3.IV.43	none	Kinneret	Febr. '43	79	71
						March '43	75	67
	Tirat-Tsvi	I.42	22.IV.42	moderate	Tirat-Tsvi	Febr. '42	74	63
						March '42	79	68
						April '42	64	46
4. Harod Valley	humidity data for localities of mildew outbreaks not available							
5. Western Valley of Esdraelon	Ramat David	III.42	9.VI.42	slight	Nahalal	May '42	65	46
						April '42	72	57
	G'vat	II.43	26.V.42	none	Nahalal	March '43	79	69
						April '43	80	68
						May '43	75	58
6. Northern & central coastal plain	Petah Tiqva	I.41	25.IV.41	none	Petah-Tiqva	Febr. '41	74	67
						March '41	78	71
						April '41	71	63
	Herzlia	II.43	4.VI.43	none	Petah-Tiqva	March '43	68	62
						April '43	76	67
						May '43	76	63
7. Southern coastal plain	Givat Brenner	II.43	20.VI.43	none	Rehovot	April '43	72	57
		III.43				May '43	67	51
						June '43	69	53
	Givat Brenner	IX.43	13.XII.43	trace	Rehovot	Oct. '43	65	51
						Nov. '43	64	56

of disease development at higher humidity levels. A border line case is represented by the record made in autumn 1943 in the southern coastal plain, at Givat Brenner. Here a trace of powdery mildew was found after humidity in October had reached 51%, while the same mean in spring 1943 failed to result in the appearance of the mildew.

ii. *The powdery mildew on cucumbers*

Records of the *Oidium* on cucumbers in 1940-1943, together with mean humidity data recorded at the nearest meteorological station (1), are presented in table IV.

In the data set out in table IV we are unable to discover any connection between outbreaks of powdery mildew on cucumbers and monthly mean humidity data for either the 24-hour period or the day-time period. Severe epiphytotics ensued within 8-10 weeks of sowing under extremely dry conditions in the Beisan Valley (Tirat Tsvi, 1941), under fairly dry conditions in ahe Southern coastal plain (Givat Brenner, 1943) and under definitely humid conditions in the central coastal plain (Mikve Israel, autumn 1940). In other cases equally humid conditions (Mikve Israel, spring 1940) or moderately dry conditions (Dafna, 1942) failed to induce such epiphytotics.

Examination of mean hourly temperature data for the months and localities set out in table IV has given us no conclusive indication that temperature might be the factor decisive for the development of cucumber mildew at various levels of humidity. With mean monthly humidity at 74%, the slight development of the disease in the Upper Jordan Valley in early autumn (Kinneret, September 1942), might be related to the high temperature (24-hour mean of 28°C); likewise, at practically the same level of humidity (75-76%) the relatively low spring temperatures of the coastal plain might have played a part in keeping disease incidence slight up to the end of May at Mikve Israel in 1940 and 1943 (24-hour mean for May of 20.2 and 20.7, respectively). However, in our view the temperature level was always a secondary factor.

Differences in either humidity or temperature conditions, as reflected in our macroclimatic data, appeared to us to be exceeded in their importance for the development of cucumber mildew by the age of the plants and the conditions of irrigation as well as by the amount of inoculum available. These factors will be made the subject of later studies.

DISCUSSION

Daily period of climatic records

In its search for climatic records indicative of conditions likely to lead to disease outbreaks, research in Israel has hitherto concentrated on downy mildew diseases, rampant during the summer

TABLE IV.

Records of cucumber mildew in relation to humidity and temperature data

District	Details of record: Locality	Date of sowing	Date of record	Degree of infection	Meteorological data: Locality of met. station	Month and year	Monthly means: % rel. humidity 24 hrs.	% rel. humidity 8 a.m.—19 p.m.	hourly temp. °C 24 hrs.	hourly temp. °C 8 a.m.—19 p.m.
1. Northern Hule	Dafna	VIII.42	23.IX.	none	Dan	Aug. '42	71	55	25.4	29.3
						Sept. '42	73	58	23.0	26.8
			16. X.	slight		Oct. '42	67	56	20.7	24.0
2. Southern Hule	no records of cucumber mildew available									
3. Upper Jordan & Beisan Valleys	Tirat Tsvi	1.IX.41	23.XI	severe	Tirat-Tsvi	Oct. '41	63	48	not available	
						Nov. '41	61	49	20.1	23.2
	Kinneret	VIII.42	16. X.	slight	Kinneret	Sept. '42	74	66	28.0	31.3
						Oct. '42	67	58	24.8	27.3
4. Harod Valley 5. Western Valley of Esdraelon	humidity data for localities of mildew outbreaks not available									
6. Northern & central coastal plain	Mikve-Israel	IV.40	1.VI.	trace	Tel-Aviv	April '40	81	73	18.6	21.5
						May '40	75	70	20.2	23.4
						June '40	84	81	24.5	27.8
		VIII.40	23.IX.	trace	Petah Tiqva	Sept. '40	81	72	24.8	27.3
			28. X.	severe		Oct. '40	80	70	23.3	26.0
		III.41	17. V.	trace	Tel-Aviv	April '41	73	68	19.2	22.2
						May '41	82	77	24.0	27.0
			20.VI.	moderate		June '41	72	63	24.7	27.3
		VIII.42	1. X.	trace	Petah Tiqva	Sept. '42	79	72	24.2	26.7
		IV.43	27.VI.	moderate	Petah-Tiqva	April '43	76	67	16.2	18.8
						May '43	76	63	20.7	23.8
						June '43	79	68	22.9	25.7
7. Southern coastal plain	Givat Brenner	IV.43	25.VI.	severe	Rehovot	April '43	72	57	15.3	18.6
						May '43	67	51	19.9	23.5
						June '43	69	53	22.7	26.7

months, especially *Plasmopara viticola* (3, 6) and *Pseudoperonospora cubensis* (4). Dependence of the development of these diseases during our rainless summers on nightly dewfall has focussed interest on the climatic conditions obtaining at night rather than on 24-hour means or daytime-records.

The powdery mildew of potatoes discussed in the present paper represents a type contrasting to the above. Favoured by conditions of low relative humidity, this disease can be clearly related only to climatic records of day-time periods, while 24-hour means obscure the picture.

Thus the definition of conditions conducive to outbreaks of fungi with very marked humidity relationships demands concentration on that part of the day when humidity remains within the fairly narrow range tolerated by the fungus. Only then the other factors influencing the parasite's development, foremost among them the level of temperature, come into play. By contrast, the powdery mildew of cucumbers is not confined in its development within such narrow ranges of relative humidity and here other factors may be held to assume a decisive influence that makes itself felt over most, or the whole, of the 24-hour daily period.

Humidity relationships

While many powdery mildews have been characterized as tolerant of low humidity (9), the only such disease so far shown to be actually restricted to conditions of low humidity is, as far as we are aware, the tomato mildew, which is of the *Oidiopsis* type (*O. taurica*). Both laboratory work zy Zwirn (10) and field surveys by Reichert and Palti (7) have indicated this. The powdery mildew of potatoes appears to be the first *Oidium* type for which field observations show a similar restriction to low humidities. According to parallel observations we have made of the occurrence of the two diseases in many parts of Israel over about ten years, there is no doubt that the potato mildew is even more restricted in this respect than the tomato mildew.

By far the most penetrating study of humidity relationships of powdery mildews has been published by Yarwood (8), who included a powdery mildew on cucumbers (*Erysiphe cichoracearum*) among the diseases he investigated. He concludes that this and several other powdery mildews can develop luxuriantly over a wide range of relative humidities and that they are well-adapted to dry atmospheric conditions, especially where temperatures are not too high. At the same time, stating that under shade conditions development of some mildews is often more severe, Yarwood stresses the importance of indirect effects of such environments, such as lower air temperature, greater vigour and succulence of plants and thinner cuticles. All Yarwood's conclusions agree with our observations to the effect that our cucumber mildew has a wide humidity tolerance.

As probable factors decisive for the incidence of this mildew on cucumbers and related crops in Israel, attention should be paid to the age of the plants and the mode, rate, and frequency of irrigation. Particulars of irrigation seem of special importance as overhead sprinklers are used on most vegetable crops in Israel, and YARWOOD (8, 9) has repeatedly stressed the injurious effect of rain on the superficial mycelium of powdery mildews.

SUMMARY

Three years' observations on the occurrence of powdery mildew diseases (*Oidium sp.*) on potatoes and cucumber are brought into relation with macroclimatic humidity records of the localities in which their presence or absence was noted.

Seven districts of Israel are characterized by presentation of 3-6 years' figures for their monthly means of relative atmospheric humidity.

Observations showed the potato mildew to be absent from the humid coastal plain and to be most frequent and severe in the drier districts. No such connection with the level of humidity could be traced for the cucumber mildew.

Fitting specific field observations of these mildews to the data recorded at the nearest meteorological station for the 1-2 months preceding the observation, it appeared that outbreaks of potato mildew can be linked with periods in which the mean percentage of atmospheric humidity between 8 a. m. and 19 p. m. falls below 50%. Development of cucumber mildew, on the other hand, could not be related to any definite level of humidity. Nor did the monthly mean temperature offer a clue to the severity of powdery mildew on cucumber, which is thought to be influenced primarily by the age of plants and cultural or irrigation factors.

LITERATURE CITED:

1. ASHBEL, D. (1944?)—Meteorological data for Palestine, Jerusalem, 73 pp.
2. ASHBEL, D. (1945) — Temperature and relative humidity in Palestine and surrounding countries. Jerusalem, 86 pp.
3. AVISOHAR-HERSHENSON, Z. (in preparation) — Phenological observations on downy mildew of vine in Israel.
4. DUVDEVANI, S., REICHERT, I., & PALTI, J. (1946) — The development of downy and powdery mildew of cucumbers as related to dew and other environmental factors. *Palestine Journ. Bot., Reh. Ser.,* 4(2) : 59—76.
5. RAYSS, T. (1947) — Nouvelle contribution à l'étude de la mycoflore de Palestine. *Palest. Journ. Bot., Jer. Ser.,* 4(2) : 59—76.
6. REICHERT, I. (1927) — Downy mildew (Plasmopara viticola) of the vine in Palestine. *Yedeoth,* 7—8, 28 pp. (Hebrew with English summary).

7. Reichert, I., & Palti, J. (1946) — Powdery mildew of tomatoes. *Hassadeh* 26; 547 (Hebrew). Abstr. in R.A.M. (26(4): 147, 1947.

8. Yarwood, C. E. (1936) — The tolerance of Erysiphe polygoni and certain other powdery mildews to low humidity. *Phytopathol.* 26:845—860.

9. Yarwood, C. E. (1950) — Dry weather fungi. *California Agriculture.* 4(10): 7 & 12.

10. Zwirn, H. E. (1943) — Studies on Leveillula taurica (Lév.) Arn. *Palest. Journ. Bot., Jer. Ser.,* 3(1): 52—53.

CONTROL OF THE POWDERY MILDEW OF VETCHES BY AIRCRAFT SULPHURING

By J. PALTI and S. ELLERN, Tel-Aviv

The powdery mildew of purple vetch (*Vicia atropurpurea*) has been known in Israel for some fifteen years. However, vetch seed used to be imported from abroad, and the crop was grown for haymaking only. Thus the mildew, appearing when the crop was about to be cut, was of little economic importance. The position changed when local seed production was begun, as spring attacks of the mildew at the seed-ripening stage causes considerable losses. In 1950, seed crops suffered severely in the Upper and Lower Galilee, the Plain of Esdraelon and the Coastal Plain, and a trial for the control of this mildew by sulphur dusting was then laid down. In view of the fact that ground conditions in early spring render the ground application of chemicals to the vetch crop very difficult, if not impossible, an attempt was made to control the disease by aircraft application of the sulphur dust.

DESCRIPTION OF THE DISEASE

The powdery mildew appears at first on the lower leaves, mainly on the upper, more rarely on the lower surface of the leaflets, with a typical white and powdery covering. The mildew then spreads upwards until the entire foliage, with the exception of the youngest leaves, is affected. At the same time the lower leaves turn yellow, dry up, and finally shed; this process also continues in an upward direction in the wake of the mildew covering. A badly attacked plant therefore has a few green leaves at the top 5-10 cms, below these there are 15-30 cms with leaves entirely covered by mildew, while the bottom leaves are shrivelled, dry and few in number and a considerable part of the stalk is bare.

The infected material was submitted to Professor Dr. T. Rayss, of the Department of Botany of the Hebrew University, Jerusalem, for identification of the causal fungus. In the absence of perithecia, the mildew can for the time being only be referred to as *Oidium erysiphoides* Fr.

METHODS

The trial was carried out on a seed crop of purple vetch at Gan Shmuel settlement in the Central Coastal Plain. The field measured 500 by 200 metres, and two strips, each 10 m. wide, were marked with flags and dusted with yellow sulphur from a Piper Cub J-3 aircraft, at the rate of 4 kg per dunum (35 lbs per acre).

The strips were marked off across the width of the field, one in its northern and one in its southern part, about 250 m. apart.

Before treatment, on May 5th 1950, the vetches were found to be in flower, with their leaves dried up from mildew attack up to ⅓ or ½ of the plants' height; the leaves higher up on the stalk were covered with mildew to varying degrees. The first sulphur dusting was applied on the 7th May. On May 11th there was a 4 mm rainfall, and inspection on the next day showed an even higher degree of mildew attack on the whole field, including the treated strips. A second treatment was therefore applied on May 17th.

To assess the results, a count was taken on May 25th. 50 plants were examined at random in each treated strip and in two places in the northern and southern portions of the untreated field. On each plant the extent of desiccation of the lower leaves and of mildew coverage on the green leaves were determined separately.

RESULTS

Superficial inspection on May 23rd showed the field as a whole to have dried up and to have assumed a greyish colour, with the exception of the treated strips which stood out markedly owing to their green colour. The mildew cover on the treated leaves had largely disappeared.

The results of the count taken 2 days later appear in table I.

TABLE I.

The effect of sulphur dusting by aircraft on powdery mildew development on purple vetch

	sulphur dusted			*untreated control*		
	N plot	S plot	% average	N plot	S plot	% average
			1. *Extent of Desiccation*			
No. of plants with leaves dried up:						
a) up to ½ height	16	20	36	5	0	5
b) up to ¾ "	29	28	57	10	3	13
c) up to full "	5	7	7	35	47	82
Total	50	50	100	50	50	100
			2. *Degree of Mildew Coverage*			
No. of plants with leaves covered by mildew:						
a) not at all	37	44	81	3	0	3
b) up to ½ leaf area	11	0	11	0	0	0
c) up to ¾ " "	1	4	5	8	0	8
d) up to full " "	1	2	3	39	50	89
Total	50	50	100	50	50	100

The table indicates that of the untreated plants more than 80% had dried up completely whereas of the sulphured plants only 7% were without any green leaves. As for the degree of mildew coverage of the remaining leaves, it is rather remarkable that 80% of the sulphured plants showed no mildew at all, while in the control plots there was hardly a leaf without mildew cover.

CONCLUSIONS AND SUMMARY

Aircraft application of sulphur dust proved highly effective in checking the attack of powdery mildew on purple vetch. As far as we are aware, no other instances of succesful mildew control by aerial sulphuring have so far been reported.

The number of applications required may be assumed to depend largely on the rainfall. As the disease seemed hitherto erratic in its appearance, the first treatment should be delayed until some symptoms of disease have been found in the vicinity. Rain in April or May appears to favour the development of this mildew and simultaneously washes off the sulphur deposit, necessitating re-treatment. The sulphur treatment can conveniently be combined with the insecticidal treatment required in many vetch seeds crops in spring.

Acknowledgements. We are indebted to Professor T. RAYSS, Department of Botany, Hebrew University, Jerusalem, for permission to quote her temporary identification of the fungus, and to Mrs. R. ELLERN for assistance in the field counts.

NOTES

EXPERIMENTS ON GERMINATION OF IMMATURE CITRUS SEEDS

By Y. Patt
Section of Citriculture, Ministry of Agriculture, Government of Israel.

Nurserymen in Israel use to sow in winter the seeds of early ripening stock varieties, like sweet lime. This implies the arrangement of seed-beds under glass. Storage of the seeds until spring when the seed-beds can be arranged in the open, not always proves successful.

When the present author investigated sweet lime fruit in September, i.e. two to three months before their maturity, he found that the seeds had nearly attained their ultimate shape and size though their colour was more greenish than is the case later on. This raised the hope that they could be germinated already in late summer or early autumn thus avoiding considerable expenses for the raising of nursery material and saving time.

Part of sweet lime seeds extracted from fruit on August, 10, 1951 was sown in dishes on blotting paper and kept at room temperature. The rest was sown outdoors. The former yielded 80, the latter only 30% seedlings. Of another lot sown outdoors on August, 21, also 30% were obtained. Later on, it was found that the unsatisfactory results of the outdoor sowings partly or wholly derived from too deep planting of the seeds (4cm).

Sowing in September proved more successful. After planting sweet lime and citron (*Citrus medica*) seeds at the Government's horticultural stations at Zerifin (Sarafend) and Acre, it was found that germination both set in and ended earlier than was the case with seeds sown in August. The ultimate percentage of seedlings obtained was higher. Thus at Acre, seedlings from sweet lime seeds sown on August, 20, at a depth of 2 cm came through the ground on Sept. 15, i.e after 26 days reaching the ultimate 30% of effective germination on Sept. 25. On the other hand, seed sown on Sept. 9, emerged on Sept. 25, i.e. after 16 days. After 31 days, germination ended, yielding 55% seedilings. Citron seed behaved in a similar manner, but rendered somewhat better results.

Seedlings of both sweet lime and citron were not adversely affected by cold during the following winter which was mild. Average minimum temperatures were $+7-8°C$, and only occasionally $+5°$ were attained.

Encouraged by the rather favourable results, we planted in 1952 seed from unripe fruit of rough lemon, sour orange, and sweet orange "Baladi", in addition to the varieties tried out earlier. From sowings made outdoors on August, 22, no germination was obtained with sour and sweet orange while rough lemon ultimately reached 60%, citron about 50%, but sweet lime only 4%. It seems important to add that seed from sweet orange was taken from trees budded on sour orange which is a stock delaying maturity. From late sowings (Oct. 20), we obtained again fair results with rough lemon and citron, but poor results (11%) with sweet lime. Sour and sweet orange yielded about 40% seedlings.

The results so far obtained suggest that the capacity of germination first reaches a satisfactory degree in September with the early ripening varieties of the lemon group, but only in October with the later ripening sour and sweet orange varieties tested so far.

While the behaviour of sweet lime in 1951 fits this hypothesis at least for the seeds planted outdoors, its low germination in 1952 does not. Possibly, the disappointing results in 1952 can be explained by the fact that the seeds were taken from sweet lime on sour orange root while in 1951, they originated from seedlings trees. But if this explanation were right, better results would be expected from later sowings when even sour orange seeds yielded a considerable percentage of seedlings. Therefore, we sought another explanation. Investigating meteorological conditions, we found that from April to September, 1952, average humidity had been at Zerifin by 6.3% higher than the average of the preceding ten years. Possibly hereby maturity of the fruit was somewhat delayed. Yet this circumstance would hardly offer a satisfactory explanation for the different behaviour of sweet lime alone in the two consecutive seasons, while no such difference was found with rough lemon and others.

Thus, further experimentation seems necessary, before it can be decided if early sowing of sweet lime will prove successful in average years, and which factors are responsible for the large fluctuations of its germinative capacity in consecutive yearly periods.

GROWTH ANALYSIS OF CARNATION GROWN IN FULL SUN AND UNDER COVER

By S. P. MONSELISE
Faculty of Agriculture, Hebrew University, Rehovot.

The high radiation prevailing in Israel during summer months may be presumed to have an adverse effect on blooming, growth and carbon assimilation of carnations. No growth analyses of

carnation seem to have been carried out to date, and very little is known on growth and carbon assimilation of these plants. For these reasons experiments had been planned to investigate the intensities of these physiological processes in different carnation varieties grown in part in full sun and in part under cover. For reasons beyond our control the experiments had to be curtailed and eventually interrupted. Only few data on the behaviour of the variety Légion d'Honneur could be collected; they are considered of sufficient interest to be briefly reported here.

As cover we chose a net of the type used to camouflage weapons of war. The percentage of light it transmitted was approximately 40% of the full sunlight.

Seedlings of the above variety, sown in December 1950, were planted in beds of sandy soil during May of the following year, and were grown there till early in September. Samples of ten seedlings each, from covered and uncovered plots were uprooted on July 2nd, July 17th, August 20th, and September 4th, 1951. Net assimilation rates(Ew), relative growth rates(R) and leaf weight/total weight ratios (Lw/W) were calculated for two fortnightly intervals, i.e. those between the first and the second pair of dates. Prior to these calculations, total weight and leaf weight at the beginning and at the end of each harvest interval were corrected by means of (a) regressions of total weight on the product of initial leaf number by initial seedling length (for total weight) and (b) regressions of leaf weight on initial leaf number (for leaf weight). A procedure similar to this had been applied previously([1]) to citrus.

On both occasions, Ew and R values were found to be lower in the shade than in the sun, as apparent from table I.

We learn from the table that Ew as well as R were much lower during the second harvest interval when plants were in full bloom, than during the first, when they were just beginning to bloom.

TABLE I

Net assimilation rates(Ew), *relative growth rates*(R) *and leaf weight/total weight ratios*(Lw/W) *of Légion d'Honneur carnations grown in shade or sunlight, during two fortnightly intervals.*

Interval	Ew*) sun	Ew*) shade	R*) sun	R*) shade	Lw/W**) sun	Lw/W**) shade
July 2nd — July 17th	9.777	6.600	3.683	2.801	0.377	0.424
Aug. 20th — Sept. 4th	3.703	1.923	1.193	0.635	0.322	0.330

*) in gms/100 gms per day **) in gms/gms

(1) Palestine Journal of Botany, Rehovot, Series 8, 54—75, 1951.

We also recorded the number of flowers produced (which were periodically picked) and the total growth in length of shoots of twenty plants grown in the sun and of twenty others grown under cover. Shaded plants averaged up to August 26, $3{,}089 \pm 300$ cms. shoot length and 8.3 ± 1.3 flowers as against $4{,}856 \pm 803$ cms. and 27.9 ± 4.7 flowers for plants grown in full sunlight. Notwithstanding the very high coefficient of variability, these differences are significant at the .05 and the .01 levels, respectively.

The length of flower stalks did not differ significantly in the sun and under cover.

On September 3rd, the osmotic value of leaf sap (tested cryoscopically) averaged 9.9 atmospheres for leaves of shaded plants and 10.7 for leaves of plants exposed to the sun. This is a small, though not negligible difference.

Thus carnation plants protected from the very strong radiation prevailing during the summer in Israel, did not show favourable responses. On the contrary, they developed at a slower rate than unprotected plants, due to reduced carbon assimilation which was not counterbalanced by slightly larger assimilating surfaces (higher Lw/W ratios). In our previous study (loc. cit.) citrus seedlings growing in the shade approximately equalled the assimilation, but surpassed the growth rate of those grown in the sun, owing to higher Lw/W ratios. Higher Lw/W ratios seem to be a consequence of a less xeric habitat as artificially produced under cover. The different response of carnation and citrus to shade may tentatively be explained by the heliophilous character of the former species in contrast to the more sciophilous character of the latter. In carnations blooming was further delayed and reduced by shade; this is not surprising. Shaded seedlings did not evince a rate of shoot elongation greater than those growing in the full sun, since the reduction of light intensity was too small to produce etiolation.

BLACK LEG OF POTATOES IN ISRAEL

By ZAFRIRA VOLCANI

Division of Plant Pathology, Agricultural Research Station, Rehovot.

Symptoms of black leg were recorded in Israel for many years during the spring season (March-May), by REICHERT[1] and by LITTAUER and co-workers[2], on young plants sown from certified seeds imported from Ireland and Scotland.

The disease affected the base of the shoots which became shriveled and blackened, and extended upwards on the stems, causing in most cases the wilt of the entire shoots. Small numbers of the

1) REICHERT I., Palestine: Diseases of vegetables crops (1939). *Inter. Bull. of Plant Protection*, Rome, Year XIII, No. 10, p. 238 M.

2) LITTAUER F., & ZIMMERMAN S. (1945).—Growing Seed Potato, *Hassadeh*, 25, pp. 404 (In Hebrew).

affected plants, however, survived and reached the stage of forming new tubers.

These symptoms were never observed during the autumn nor on plants sown from local seeds. However, during the spring season of 1952 and 1953, the disease was recorded by S. ZIMMERMAN-GRIES, in plots sown from local seeds, to the amount of 1—2%.

No attempts have been made, so far, to isolate and identify the causal organism. During the spring of 1953 a great number of plants showing black leg symptoms were examined. They comprised the varieties "Up to Date" (local and imported seeds), and "Arran Banner" (seeds imported from Ireland and Scotland). The incidence of the disease amounted to 0.2—2%. A bacterial organism was isolated in pure culture from infected parts of the stems and the base of the shoots.

Text-fig. 1. Young potato plant, inoculated with the Israeli isolate of *Erwinia atroseptica,* showing the extension of infection on the stems 4 days after inoculation.

Inoculation of these isolates, by puncturing the stems of healthy plants, under conditions of high humidity, produced symptoms similar to those observed on diseased plants in the field (text-fig.1). The reisolated organism was identical with the original isolations.

Examination of the local isolates along with British (Isolate 17(a) DOWSON) and American (274,276 BURKHOLDER) cultures of *Erwinia atroseptica,* the causal organism of black leg, showed great similarity with the latter ones.

The organism was finally identified as *Erwinia atroseptica* (van Hall) JENNISON[3].

[3]) BERGEY H., BREED R. S., MURRAY E.D.G., PARKER-HITCHENS, A. (1948). Bergey's Manual of Determinative Bacteriology, *Williams and Wilkins Co.,* Baltimore, U.S.A.

LIONELLO PETRI
1875—1946

(*Appreciation and Memories*)

The news of the death of this great scientist, and of the irreplaceable loss this meant to Italy and to world science, reached us but late due to the World War and afterwards to Israel's War of Independence. Thus it is almost six years after the death of this scholar that I find myself writing this special appreciation in his memory. I had wanted this appreciation to appear on the fifth year

after his death, but here again the publication of this journal was delayed due to circumstances over which we had no control.

This appreciation is but a small return for the great debt I owe him. In 1921, I worked under PETRI's direction for about two months at the Instituto Forestale Superiore in Cascine near Florence. This short period of work with him was very dear to me, not only because of the quiet atmosphere and the beautiful surroundings in the vicinity of Florence, but also because of the happiness I felt in the proximity of this great man.

During my eleven months stay in Italy I worked in many of the mycological and pathological laboratories of that country, from Genoa on the Riviera to Acireale in Sicily. But it was only

in Florence under PETRI that I felt the dynamic scientific atmosphere that I had so longed for and which was so difficult to find even in Central Europe.

PETRI directed me in experimental research on the effect of ultraviolet rays on *Cyclonium oleaginum,* the causal agent of leaf fall in olive tress. Even at the beginning of my work, I immediately felt the breadth of PETRI's knowledge in exact sciences and his great talent for experimental methds. PETRI was outstanding amongst the phytopathologists and mycologists of the world in his comprehensive knowledge of all branches of science. He was a living encyclopaedia of knowledge and was able to utilise it all in his work. He was not only a phytopathologist, mycologist and biologist, but also an important physicist. It was for this very reason that his researches were so varied, but in spite of the extensiveness of his field of study he never once lost sight of practical objectives. His connections with practical agriculture in Italy were very close indeed. PETRI's investigations on chestnut, vines, olives, and citrus trees are classics and will always remain so.

In his work PETRI distinguished himself not only quantitatively but also qualitatively. Though there are a few phytopathologists in the world who investigated and published as profusely as PETRI, no pathologists tackled his investigations with such varied methods; including taxonomic, physiological, biochemical, and biophysical approaches, and there was no phytopathologist of his time whose researches were as penetrating as those of PETRI. No problem was too complicated: his analytical and experimental ability overcame all difficulties.

It will be sufficient to mention but two of the investigations carried out by PETRI: on the "Ink Disease" of chestnut and the problem of "Malsecco" in citrus trees. The generations of investigators that preceded him failed in its efforts to solve these two problems that included, in fact, a number of diseases. I remember that in 1921 when I visited Prof. LUIGI SEVASTANO, he related to me his opinion that the "Malsecco" disease, gummosis of branches, trunk, and root of citrus trees were all caused by a bacterial organism. PETRI afterwards revealed that all these symptoms were caused by three organisms: *Phytophthora citrophthora* causing gummosis of the trunk and root, *Bacterium citriputeale* causing gummosis of the branches, and finally *Deuterophoma tracheiphila,* the causal agent of "Malsecco" in lemon trees. Such was PETRI's ability in the disentanglement of even the most involved problems.

The phytopathological problems investigated by PETRI were often far removed from one another. His two hundred and seventy publications, both books and papers, constitute a record that no other phytopathologists has reached. And all his published works, even the most general and popular, are fundamental, original and instructive.

It is only by compairing PETRI to the phytopathologists of his generation in Italy that one can fully appreciate his great genius.

When PETRI began his work, the field of phytopathological research in Italy was dominated by investigators like CAVARA and BRIOSI — scientists of great importance in their knowledge of pathogenic fungi but superficial in their understanding of pathological processes. Even CUBONI, who went more deeply into the problems of plant diseases, remained remote from a full understanding. PETRI made his way in phytopathology without help from others. He created a new period in the science of phytopathology in Italy and educated a whole generation of phytopathologists, by his writings and personal influence. The journal "Bollettino della Stazione di Patologia Vegetale", that he published for 17 years, rivaled the finest journals in the world. I have the impression that PETRI's influence in Italy spread not only throughout phytopathology but throughout all agricultural sciences. If Italy is able to publish a journal as fundamental and important as the "Anali della Sperimentazione Agraria", this may to no small measure be ascribed to PETRI's influence on the young scientific workers of Italy.

In spite of the breadth of his knowledge in general and of theoretic sciences, PETRI never allowed himself to be absorbed by details. His morphological descriptions of bacteria and fungi reached a completeness that was rare even amongst the best of the systematicists. All his days PETRI was especially attracted by a group of non-pathogenic fungi — the *Gastromycetes*. His love of these fungi was a result of the influence of his teacher, Prof. MATTIROLO, the great specialist in this group of fungi. The important monograph written by PETRI on the *Gastromycetes* in the cryptogamic flora of Italy is one of the best and most fundamental works on this subject. Whenever I had the opportunity of using this work I became very conscious of the accuracy and originality of his descriptions.

In spite of his analytical ability and scrupulousness for details, PETRI had a deep and inherent tendency towards synthesis. This can be seen from his various investigations, and in particular from the 17 reviews ("Rasegna") that he published in his journal "Bollettino" during the years 1921-1942. These reviews are masterpieces of writing. I have never read in any other language of the world reviews on plant diseases as interesting and fundamental as those by PETRI. It is indeed a great pity that PETRI never found time to write a comprehensive book on plant diseases; a book that would undoubtedly have become a classic.

In spite of the monumental work carried out by PETRI, and the time and attention it must have demanded, he was a man of warm and friendly sympathy towards his friends and colleagues in need of scientific aid. His love of humanity was directed not

only towards his fellow countrymen but towards all men. He recognized no frontiers in his desire to help. I would like to relate one example that well illustrates how ready PETRI always was to render help when needed. Close to the outbreak of the Second World War I wrote to him requesting seeds of two lemon varieties, Donatello and Monachello, which are resistant to the "Malsecco" disease, then prevalent in Israel. In order to camouflage from the Fascist authorities the shipment of the seeds, he requested us by telegraph to send him in return seeds of the Marsh grapefruit. I new at the time that he had no need for such seeds, since during my stay in Italy I had noticed many Marsh grapefruit trees of different origin in his experimental plots. His request was merely a subterfuge in order to conceal from the Fascist authorities the export from Italy of seeds of resistant lemon varieties — in order that the shipment might appear to be a normal scientific exchange. Before I managed to send him in return the Marsh grapefruit seeds, the last "Ala Littoria" plane to reach Israel before the outbreak of the World War brought with it the lemon seeds I had requested.

With the outbreak of the World War, the connections between us were severed but the darkness of the wars could never blot out the genius of men like LIONELLO PETRI — the pride of the people that produced him.

I. REICHERT

Dr. EPHRAIM HAREUBENI

Dr. Ephraim Hareubeni (Rubinovitch) who deceased a month ago, was lecturer in Biblical and Talmudic Botany at the Hebrew University. His research was both biblical and botanical, and there are few persons whose knowledge embraces both fields and who are competent to appreciate his achievements

Born at Novomoskovsk in Russia, in 1881 Hareubeni immigrated, as it seems, at the beginning of the century. Wandering about in the arid south, the Hauran and in Palestine both east and west of the Jordan, he acquired an unusual knowledge of both wild and cultivated plants, and of the habits and language of the rural population. Thus he became competent to interpret debatable plant names, ambiguous phenomena in nature and symbolic expressions mentioned in the scriptures. It should be recalled that too often such exogetic endeavours by both Jewish and Christian authorities are mere speculations conceived in their study-rooms.

Whoever visited the Hebrew University on Mount Scopus in the thirties, was sure to meet here this beardy, delicate Jew with his blue, naive eyes and his enthusiastic falsetto. Together with his inseparable companion, Mrs. Hannah Hareubeni, he worked indefatigably in his sanctuary, the Museum of Biblical Botany which formed one of the main attractions for local and foreign visitors. Here, the couple created an admirable permanent exhibition of dried plant specimens preserved by ingenious methods in their natural shape and colours and kept in fine cupboards of glass. There were anemones in all colours, sages the inflorescence of which had, in Hareubeni's opinion, been the archetype of the seven-armed candlestick of the temple, and the "chatzav" announcing the approach of the rainy season, when its straight, white inflorescences appear on the parched fields. The latter species for which Hareubeni had developed a special affection, was shown in its various aspects of the dry and the rainy seasons and with the specific diseases and insects parazitizing it. In addition to the museum Hareubeni hoped also to plant a Garden of the Prophets including all the species mentioned in the Bible.

His essentially religious and emotional approach to the problems of plant structure and life contrasted sharply with that of a younger generation of natural scientists educated in the rationalistic spirit of western civilisation, though this spirit was by no means unfamiliar to Hareubeni who had studied botany and graduated from the University of Lausanne and others. This modern attitude is probably more scientific in the proper sense of the world, but it lacks the emotional merits and attractiveness to wider, popular circles, simple friends of nature for whom Ephraim Hareubeni's

death means an irreparable loss. It is also often deplorably dull, except with an intellectual elite which is both critical-exact and inspired by strong emotional stimuli.

Hareubeni's theories about plant names, etc. were not always convincing, but as a botanist he possessed great merits. He was a keen observer noticing a thousand little things which escaped the attention of others. Falling in love with his plants, he studied them thoroughly at all hours of the day. The illustrations of his and his wife's book "Thesaurus plantarum" are remarkable for their artistic beauty. His inquisitive mind and pioneering energy led him on untrodden paths and, still as an old man, he would, as the prophet Amos, climb an old sycamore tree in a populated street of Tel-Aviv, as if he were still a boy, — in order to make his observations on its upper branches.

Of his botanical achievements, we appreciate most his studies on the parasitic and half-parasitic plant species of this country. The noxious *Thesium* attacking barley fields in the Negev and the red-fruited mistletoe bush developing on the branches of the olive aroused his greatest interest. While his late colleague Alexander Eig had not thought much of the damage inflicted upon unirrigated olive trees by the mistletoe, Hareubeni's observations showed convicingly that this green half-parasite threatens the life of the infested branches, absorbing the scarce water reserves available during the dry summer months. In another article (1935), Hareubeni insisted on the great damage done to various herbs, shrubs and trees by the twining parasite *Cuscuta monogyna.* Other contributions are devoted to the folklore of Palestinian plants which he collected from bedouin and fellahin, to the use of plants in popular medicine, as fodder for bees and for their aromatic properties.

It should not remain unmentioned that Hareubeni was botanical adviser to the Department of Agriculture and Forests during the days of the British mandate and keeper of its plant collections. His name will remain unforgotten as one of the first Jewish pioneers of plant science in this country.

H. R. OPPENHEIMER

As this volume nears completion, Professor RICHARD FALCK, the veteran mycologist, celebrates his 80th birthday in Atlanta, Georgia, U.S.A. The editors of this Journal join his many well-wishers in all countries in warmly congratulating Professor Falck, and have decided to dedicate to him the next volume of the Journal.

ד״ר אפרים הראבני ז״ל

ד״ר הראבני שנפטר פתאם בחדש שעבר בגיל 72, עלה ארצה מרוסיה לפני 47 שנה. הוא היה מרצה לבוטניקה תנ״כית ותלמודית באוניברסיטה העברית בה הקים, יחד עם ראיתו חנה, את בית הנכאת לצמחי התנ״ך. בסיוריו הרבים בארץ ובארצות השכנות רכש לו ידיעות רבות על צמחי־הבר ואלו הגדלים בשדות הזרועים. הוא רשם מפי התושבים פרטים יקרי־ערך על השמוש בצמח לצרכי רפואה ועל תפקידו במסורת־העממית ובאגדות; ועל סמך ידיעותיו אלו פירש שמות צמחים בכתבי־קדש ופיענח פסוקים סתומים. בכתביו עמד הראבני על השמיר, החצב והיבלית המזדהה, לפי דעתו, עם מה שרגילים היום לקרוא בשם עידית (Asphodelus). בספרו „אוצר צמחי א״י" שהוציא יחד עם חנה, הוא נתן לנו מונוגרפיה רבת ערך על החצב והיבלית. מחקריו המוקדשים לטפילים ולחצאי הטפילים הירוקים ראויים לציון מיוחד. כאן הוכיח הראבני כי דבקון הזית הנפוץ בירושלים, מזיק מאד לענפי הפונדקאי בהם הוא משתרש בגוזלו ממיהם בחדשי הקיץ היבשים.

הראבני ייזכר לנצח כאחד מחלוצי הבוטניקה המובהקים בישוב העברי המחודש.

ה. ר. אופנהימר

בתפו״אד קדמו תקופות שבהן ירדה הרטיבות היחסית הממוצעת של האויר, מתחת ל־50%. לעומת זאת לא נקבע כל קשר בין מידת הרטיבות היחסית לבין הופעת הקמחון במלפפונים. גם רמת הטמפרטורה הממוצעת בתקופות אלו לא השפיעה כנראה באופן מכריע על הופעת מחלה זו.

הדברת הקמחון בבקיה ע״י גפור מאוורין

מאת י. פלטי וא. אלרן

מאמר זה הודפס במלאו ב„השדה״, כרך ל״א, חוב׳ י׳, עמ׳ 513־514, תשי״א.

הנבטת זרעי הדר בלתי בשלים

מאת י. פת

זריעתם של זרעי הדר בקיץ או בסתו המוקדם, לפני הבשלתם המלאה של הפירות — אם תוכתר בהצלחה — עשויה לשחרר את השתלן מהצורך בהתקנת מנבטה חורפית מכוסה. לכן בוצעו כמה נסיונות של זריעת זרעי הדר בלתי בשלים. אף כי התוצאות אינן מאפשרות עדין להסיק מסקנות סופיות, נראה כי ניתן לזרוע בהצלחה מסויימת את המינים המקדימים להבשיל (כגון הלימון הגס) כבר בספטמבר, ואילו זנים אפלים יותר (חושחש, ת״ז מתוק) נוכל לזרוע באוקטובר. בלימטה המתוקה הושגו בשתי עונות זריעה תוצאות סותרות.

ניתוח הגדילה של שתילי צפורן הגדלים בשמש או בצל חלקי

מאת שאול פ. מונסליזה

שעור ההטמעה הממשית ושעור הגדילה היחסית, נמצאו יותר גבוהים בשתילי צפורן מהזן „לג׳יון ד׳הונאר״ שצמחו בשמש מלאה מאשר בשתילים שגדלו בצלה של רשת המקטינה את ההארה ל־40% מהאור המלא. שתילי הדר שנבדקו בנסיונות קודמים, לא התנהגו כך, ועובדה זו מבליטה את האופי אוהד האור של הצפורן לעומת שתילי הדר אוהדי הצל החלקי.

גם יבול פרחי הצפורן שנתקבלו בשמש המלאה, עלה בהרבה על יבול הפרחים בצל החלקי.

מחלת הרגל השחורה על תפוחי־אדמה בישראל

מאת צפירה וולקני

המחלה גורמת להשחרת בסיסי הגבעולים, ולנבילת השיח כלו.

באביב שנת 1953 נעשה בפעם הראשונה הנסיון לברר את סיבת וגורם המחלה בארץ. בודד אורגניסמוס בקטריאלי מחלקי הגבעול הנגועים, שהוגדר כ־ Erwinia atroseptica (Van Hall) Jennison.

ליונלו פטרי

ניתן תאור פעולתו המדעית של פרופ. פטרי, מנהל המכון המרכזי למחלות צמחים ברומה, שמת לפני שש שנים. צויינו זכויותיו המדעיות במקצועות הפתולוגיה, המיקולוגיה והוירולוגיה. הוא ביצע מחקרים חשובים ויסודיים במחלות הערמון. עצי הדר, הגפן והזית. פרסם גם מונוגרפיה של פטריות הכרס. היה אוהב אדם וגם ידיד ישראל.

י. רייכרט

החומר ובנוכחותו, מופיע בתרבות גידול חדש של הפטריה, המתחיל במקום מסויים בשולי המושבה ומתפשט בצורת מניפה.

התרבויות שבודדו מהצמיחה החדשה הזאת, התפתחו באופן נורמלי. העברות חוזרות לא השפיעו על כשרן של התרבויות הנ״ל להתפתח בנוכחות הדיפניל ולכן אפשר להניח, שלפנינו גזעים חדשים של דיפלודיה, העמידים בפני הדיפניל.

עטיפת פירות תפו״ז שמוטי בניר ספוג דיפניל לא מנעה מהגזעים העמידים בפני דיפניל מלחולל רקבון בפרי. אולם, פתוגניותן קטנה בהרבה.

פתוגניות של דיפלודיה מן פונדקאים שונים לפירות הדר חלק ב.

מאת ג. מינץ

החבור מתפרסם במלואו באופן מקביל בכתבים, כרך ד׳.

העברה של רקבון העוקץ דיפלודיה ע״י מגע, בתפוחי זהב שמוטי.

מאת מינה נדל—שיפמן

מטרת העבודה היתה לבדק באזה תנאים רקבון העוקץ הנגרם ע״י הפטריה Diplodia natalensis P.E., יכול לעבר על־ידי מגע מפרי רקוב של שמוטי לפרי בריא.

לשם כך הובאו פרות בריאים במגע עם פרות רקובים בתנאי רטיבות שונים. אחרי 3—2 שבועות של מגע זה הראו הפרות הבריאים במקום המגע, פגמים בקליפה.

באיזולציות של הפגמים האלה לא נתקבלה דיפלודיה במשך השבוע הראשון אך הפטריה נתקבלה תמיד החל מהשבוע השני אחרי הווצרם של הפגמים.

תוצאות אלה מראות שהפטריה דיפלודיה יכולה לעבר ע״י מגע מפרי רקוב לבריא.

קמילת עצי אורן ירושלים והמיקוריזה

מאת י. וואהל וי. רייכרט

בארץ נפוצה מחלת אורן ירושלים הגורמת לקמילת העצים ותמותתם. הבדיקות הראו שהמחלה קשורה בהתפתחות לא נורמלית של המיקוריזה הנגרמת ע״י תנאים איקולוגיים לא נוחים לגידול העץ, כגון חשיפת הקרקע ממשטח המחטים והתיבשות הקרקע.

תצפיות־שדה על יחסי הרטיבות של שני קמחונות בישראל

מאת י. פלטי

סקירה לקביעת התפוצה של מחלות הקמחון בתפו״אד ובמלפפונים נעשתה באזורים שונים בארץ במשך השנים 1942—1944.

תוצאות סקירה זו הובאו ביחס עם הנתונים של רטיבות האויר היחסית של הרשימות המאקרי־אקלימיות באזורים אלה. התברר כי בתפו״אד לא הופיע הקמחון באזורים הלחים, אך הופעתו שכיחה וחמורה ביותר באזורים היבשים. כלפי זה לא התגלה כל יחס בין רמת הלחות היחסית לבין הופעות הקמחון במלפפונים.

לתצפיות מקומיות על הופעת הקמחונות השווינו רשימות מטאורולגיות של המקום, מ־1—3 חדשים שקדמו להופעת המחלות. התברר כי להופעת הקמחון

של פרי צעיר כשהיא מחושבת לפי המשקל הטרי, קטנה פי 40 מהתנדפות העלים. צפיפות הפיוניות קטנה אף היא בפרי מאשר בעלים.

בדיקות חיוניות של זרעי הדר

מאת שאול פ. מונסליזה

בחפוש אחרי שיטת בדיקה מהירה של כוח נביטת זרעי הדר, הנחלש במהירות גדולה עקב התיבשות הזרעים, נוסו שיטות בדיקה שונות. מידת העכירות של המים בהם נישרו הזרעים קשורה קשר ישיר עם מספר הימים שהזרעים נשארו בתנאים המאפשרים את התיבשותם. גם עצמת הנשימה קשורה במידת חיוניות הזרעים. אולם לשתי דרכי הבדיקה הנ״ל רק ענין עיוני. יותר שמושיות נראות: (א) צביעת החלקים החיים של הזרע ע״י סלניט הנתרן המוחזר לסלניום מתכתי, (ב) הנבטת זרעים מקולפים, הנובטים ביתר מהירות מזרעים שלמים. אולם שתי שיטות אלו מניבות ערכי חיוניות גבוהים מדי לעומת אחוז הנביטה בתנאי מנבטה, כי הן אינן מושפעות מעכוב הנביטה הניכר הנגרם ע״י קליפות הזרע. יתכן שעכוב זה גובר לאחר התיבשות ממושכת של הזרעים.

האופי האיקולוגי של חומעת רוטשילד

מאת ה. אופנהימר

Rumex rothschildianus הנו מין נדיר ארץ־ישראלי שהתגלה על־ידי אהרונסון בסביבת זרגניה — סמוך לבנימינה של ימינו — בתחילת המאה הנוכחית, אך מאז נאסף לעתים תחוקות. בסביבה בה נמצא ראשונה, נותר רק שטח מצומצם מאד בו ניצל צמח מענין זה מהשמדה. איג זוהרי ופינברון מצאוהו במקומות נמוכים, לחים, אך במקום בו נראה שאהרנסון גילהו, הוא שייך לצומח הכורכר המתפורר וגדל על גבעה הנישאת מעל הסביבה. נדמה שהמין הנקרא גם, לפי איג, חומעת האוירון, מסתגל לתנאי סביבה שונים.

שמוטי על כנות שונות ויחסן למחלת נקרון העצה

מאת י. רייכרט, י. יופה וא. בנטל

בשנת 1934 הרכיב ש. ידידיה המנוח שמוטי על 32 כנות שונות, בעיקר באדמת חמרה, במקוה ישראל. במשך כל השנים נעשו רשימות מדויקות על מצב העצים ויבולם. במשך השנה האחרונה נעשו הסתכלויות ובדיקות בעצים לשם קביעת ההצלחה של הכנות השונות ויחסן למחלת נקרון העצה.

הוכח שהגורם הקובע את הצלחת הכנה היא מחלת נקרון העצה. הכנות שהטיבו לעמוד נגד מחלת נקרון העצה הן: זני חושחש מישראל ומבגדד וגם ת״ז ולנסיה. נכשלו לגמרי הכנות: לימטה מתוקה, לימון גס, לימון חמוץ, אשכולית דונקן, והתלת־עלי. באדמה קלה הצליחו במידה ידועה גם לימטה מתוקה ולימון גס.

הבדיקות הראו שמחלת העלעלת מזדהה עם מחלת נקרון העצה.

סימני הנקרון נראו לא רק בכנה כי אם גם ברוכב, וגם צורת הנקרון היתה לפעמים הפוכה: החורים בקליפה והזיזים בעצה.

גזעי דיפלודיה העמידים בפני דיפניל

מאת פ. ש. ליטואר וי. גוטר

הדיפניל מעכב בדרך כלל את ההתפתחות של Diplodia natalensis P. E. מחולל רקבון העוקץ בפירות הדר. אולם, לפעמים, אחרי השפעה ממושכת של

ניתוח הגדילה של שתילי הדר. ב) השואה בין חושחש, לימטה מתוקה ולימון גס

מאת שאול פ. מונסליזה

שעור ההטמעה הממשית (net assimilation rate) בשתילי חושחש בני 9 חודשים, הנו נמוך במידה מובהקת מזה שנקבע בשתילי שתי כנות דמויות הלימון (לימטה מתוקה ולימון גס) בני אותו גיל. שעורי הגדילה היחסית (relative growth rate) היו אף הם נמוכים יותר בחושחש, אף כי לא במידה מובהקת. אפשר להסביר תופעה זו ע״י כך שכנגד שעורי ההטמעה הנמוכים מצוייד החושחש בשטח ומשקל עלים יותר גדולים באופן יחסי מאשר שני המינים האחרים.

תוצאות אלה התקבלו ע״י בחינת חלקים על־אדמתיים בלבד, אך הוכח כי היחס הכמותי של החלקים הנ״ל לשרשים, אינו שונה במידה ניכרת במינים השונים, בגיל צעיר זה. לכן מותר להניח כי המסקנות שהוסקו הולמות גם צמחים שלמים. הנתונים הנוגעים ללימטה המתוקה מתאימים לאלה שנמצאו בנסיונות קודמים, לאחר הוספת משקל השרשים לשעורי ההטמעה החדשים.

זהוי כנות עצי הדר בעזרת בדיקות קולורימטריות

מאת אהוד יונגוירט

בעזרת שיטות קולורימטריות נבדקו מינים וזנים שונים של עצי הדר; כנות, רוכבים ועצים זריעים בלתי מורכבים. התמיסות הגורמות להופעת צבעים אופיניים למין או לזן היו: תמיסת „אלמן", מוליבדאט האמוניום, כלוריד ברזלני וכלוריד הטיטניום. ברוב המקרים נבדקה קליפת הגזע.

לעתים נבחנו התמיסות הצבועות באמצעות קולורימטר פוטואלקטרי: הודות לחידוש זה מתקבלות עקומות העברת האור שונות בשביל המינים השונים, במקום שצריך להסתפק בתאור הצבעים במלים. בעזרת העקומות הנ״ל גם אפשר לגלות השפעות הכנה על הרוכב או נהפך, שאינן ניתנות להבחנה בעין בלתי מזויינת.

תמציות מימיות של אברים שונים מאותו העץ נצבעו בצבעים שונים בבדיקה ע״י אותו הריאגנט. הצבעים החזקים ביותר נתקבלו מתמציות של עלים צעירים וקליפת שרשים מבוגרים. לעומת זה נתקבלו תמיסות חסרות צבע משרשים צעירים.

התברר כי ריאקציות הצבע אינן אופיניות לעצי הדר בלבד. תמציות מקליפת עצים השייכים למשפחות בוטניות שונות הגיבו אף הן לריאגנטים הנ״ל.

מהות הצביעה לא הוסברה, אולם התברר כי התרכובות המגיבות למוליבדאט האמוניום נמסות בכהל והן שונות מאלה המגיבות לתמיסת „אלמן".

זרימת מים מן הפרי אל העלים בעצי ת״ז שמוטי

מאת אבשלום רוקח

המחבר מוכיח כי גם בעצי שמוטי קיימת, בתנאי גרעון מים פנימי, זרימת מים מן הפרי אל העלים, כמו בעצי פרי ובירקות רבים. הדבר מוכח ע״י התכווצות הפירות, ושנויים במתכונת המים והערך האוסמוטי, ובמידה מסויימת גם ע״י קביעת הגרעון עד לרויה. נמצא כי המים מועברים על נקלה מפרי הנמצא על ענף ראשי שממנו נתלשו העלים, אל ענף צדדי המצוייד בעלים. נראה כי מוצא המים המועברים, בקליפה ולא בציפה. אין מציצה ניכרת של מים מהפרי בטרם יגיע לממד של זית גדול (המשקל 8—10 ג״ר). התנדפיתו

עתון לבוטניקה

כרך ח׳, חוב׳ ב׳ סדרת רחבות חשון תשי״ד

מחקר נסיוני ביחסים האקולוגיים ונידוף המים של צומח יערני ים תיכוני

מאת ה. אופנהימר

המחבר בדק על הר ההיטרי את עצמת ההתנדפות של עלי האלון המצוי, הער האציל, בר הזית הבינוני והאלה הארץ־ישראלית, בעזרת מאזני השזירה. השפעת ההתיבשות ההדרגתית של הקרקע הסלעית החלה בין החודשים אפריל ואוקטובר, בלטה מאד בשני המינים הראשונים, בעלי עלים גלדיים־קשים. התנדפותם ירדה ביוני ובספטמבר לערכים נמוכים מאד, או אף נפסקה כליל בשעות החמות, עקב סגירת הפיוניות. לעומת המינים הנ״ל נמצאה בבר הזית התנדפות שוה ומאוזנת במשך כל הקיץ והפיוניות נמצאו תמיד פתוחות לרוחה. התנהגות זו הביאה בתום הקיץ לידי אותו הרכוז הגבוה של מוהל התאים, שתואר מקודם ע״י אחרים ואושר במחקר הנוכחי ע״י ערכים אוסמוטיים גבוהים להפליא. התנדפות האילה הנ״ל הנשירה, נמצאה גבוהה למדי באביב, אך ירדה באופן הדרגתי לרמה קיצית נמוכה. הפיוניות היו תמיד פתוחות אך מעט, ונמצאה נטיה לצמצום נוסף של פתיחתן בסוף העונה היבשה.

ביחס לרמת ההתנדפות הממוצעת במחזור השנתי, מציע המחבר להבדיל בין צמחים בעלי התנדפות גבוהה, או פוליהידריים (כגון האילה הארץ־ישראלית ומינים נשירים אחרים), ובין בעלי התנדפות נמוכה או אוליגוהידריים כגון הער והאלון המצוי; כמו כן הוא מבדיל לפי קביעות רמת ההתנדפות בין צמחים איזוהידריים, בהם השנויים במשך השנה קטנים, ובין פויקילוהידריים בהם חלות תנודות גדולות ברמת ההתנדפות. רב המינים הם פויקילוהידריים.

כוון ונטית המורד משנים, כידוע, עד מאד את התנאים המיקרואקלימיים המכריעים, לעתים, בקיום הצמחים; גדולים במיוחד ההבדלים בין מורדות דרומיים וצפוניים. על כך מעידות מדידות של דרגת חום הקרקע ורטיבותו שבוצעו בפרוס העונה היבשה. נמצאו הבדלים גדולים מאד בשכבת הקרקע העליונה, וגם ההתאדות הפיזית שנמדדה בעזרת צינורות פיש כ־40 ס״מ מעל פני הקרקע, היתה גדולה יותר במורד הדרומי (ראה טבלה 1). במורד הדרומי הנתון להשפעת השמש התחממה עד מאד שכבת אדמה דקה ויבשה, אך בנקיקי סלע גלוי היתה הטמפרטורה נמוכה ביחס, כפי הנראה כתוצאת כושר הסלע הרב להובלת חום, המאפשרת פזורו לעומק הסלע.

בפרק המתודולוגי, ניתנות הוראות בשביל השמוש בשיטת האינפילטרציה לבדיקת הפיוניות במיני חורש ים תיכוני שונים. הרחקת השערות ע״י שיפשוף מועילה להבלטת כתמי הנוזלים החודרים פנימה באלון התבור. באלונים, חרוב וער, יותר נוחה ההסתכלות בכתמים מלמעלה, מול המקום בו שמים טיפות הנוזלים.

עתון לבוטניקה
מופיע בשתי סדרות

א. סדרת רחובות:

יוצאת לאור ע"י ה. ר. אופנהימר וי. ריכרט מהתחנה לחקר החקלאות ומהפקולטה לחקלאות של האוניברסיטה העברית, רחובות, ישראל. לפי תכניתנו כל כרך בסדרה זו יכיל 2 חוברות (200—300 עמודים).

את דמי החתימה יש לשלם למפרע ע"י שק או המחאת דאר. מחיר החתימה הוא:
2.500 ל"י לכרך בעד סדרת רחובות
בסכומים אלו אינם נכללים דמי המשלוח.

ב. סדרת ירושלים:

יוצאת לאור ע"י חבר העובדים של המחלקה לבוטניקה באוניברסיטה העברית בירושלים. לפי התכנית כל כרך בסדרה זו יכיל 4 חוברות (300—400 עמודים).

את דמי החתימה ואת המכתבים הנוגעים בעניני המערכת יש לשלח לפי הכתובות הבאות:
לסדרת ירושלים: עתון לבוטניקה, ת.ד. 620, ירושלים.
לסדרת רחובות: עתון לבוטניקה, ת.ד. 15, רחובות.

את רוב הכרכים הקודמים של סדרת רחובות אפשר להשיג במחיר של 2.500 ל"י כ"א.

דפוס מ. שהם, תל־אביב, רח' פין 6, טל. 2239

עתון לבוטניקה

סדרת רחבות

(לפנים רשימות לבוטניקה ומדעי גננות)

יוצא לאור על ידי

ה. ר. אופנהימר וי. ריכרט

מהתחנה לחקר החקלאות, ומהפקולטה לחקלאות של האוניברסיטה העברית, רחובות, ישראל

מזכירי המערכת:

י. פלטי וש. פ. מונסליזה

רחבות, ישראל